The Welding Engineer

Edited by L. B. Mackenzie

$3.00 per year in U. S. | Reg. U. S. Pat. Office | $4.00 per year abroad

Vol. 7 | Chicago, Ill. 608 S. Dearborn St. | MAY, 1922 | New York 14 Vanderwater St. | No. 5

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Published Monthly by the Welding Engineer Publishing Co. Entered as Second Class Matter Jan. 20, 1916, at the Post Office at Chicago, Ill., Under the Act of March 3, 1879.

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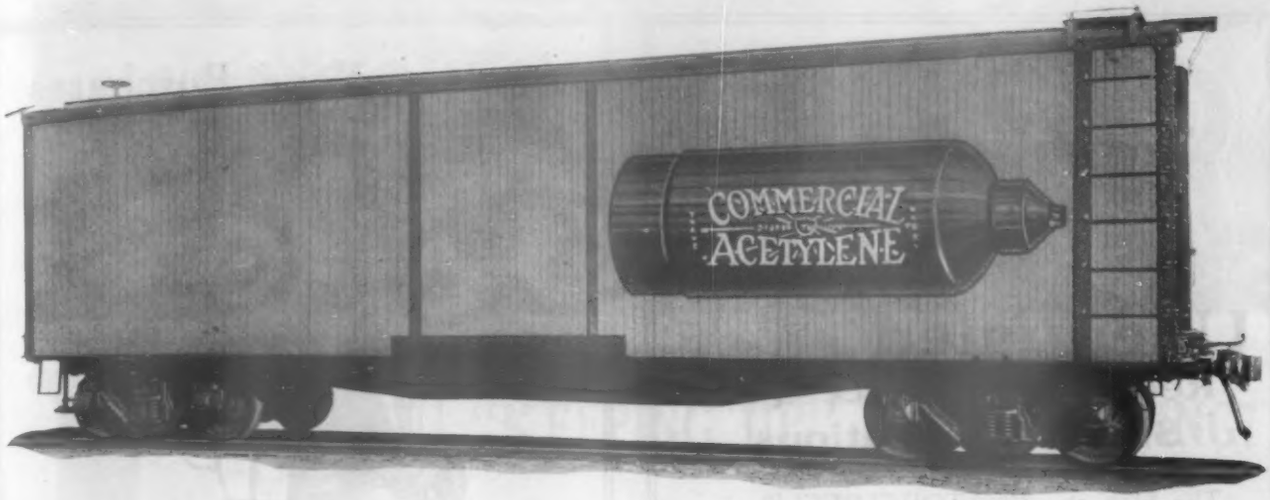

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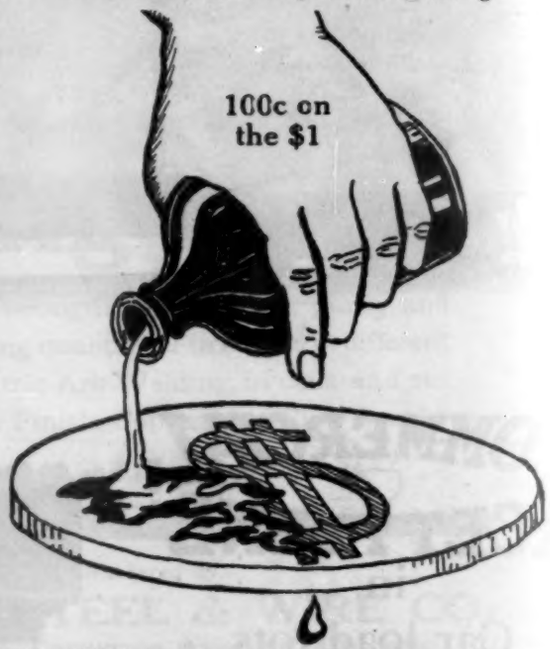

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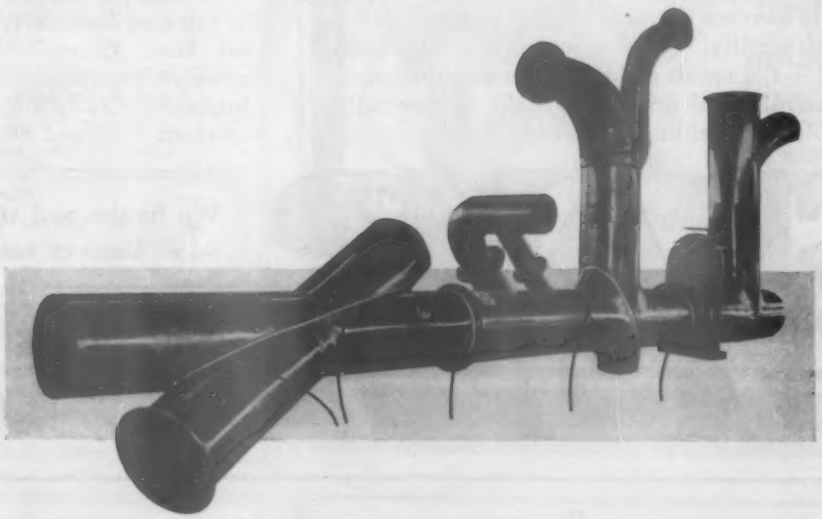

You are familiar with welding—you use it every day, but are you really keeping up with the wonderful strides welding has made in the last few years?

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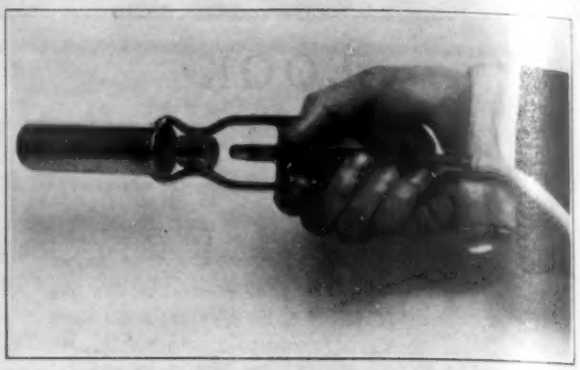

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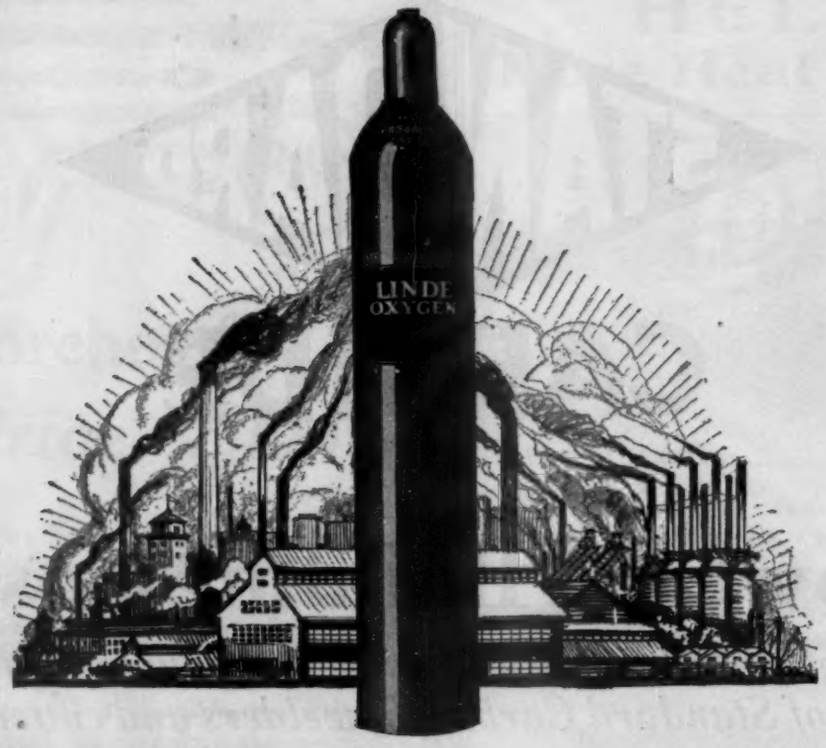

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EFFICIENCY OF MACHINE CUTTING*

Cutting With the Oxy-Acetylene Torch Can Be Made to Approach Very Closely the Maximum Theoretical Efficiency

By Fred J. Maeurer†

IN bringing before you these photographs of very unusual machine cutting operations, by the various types of machines, we particularly call your attention to four essentials of cutting that can be obtained only by taking away the human element and substituting electric power for motion and mechanical means for holding the torch; these four things are—low oxygen consumtion, speed of cutting, accuracy and smoothness of cut.

Of the four, the consumption of oxygen is by far the most important, as engineers and plant managers are always on the watch for information that will enable their operators to cut down oxygen consumption without cutting down production. It has been proven time and time again that it can be easily done if the heads of departments would compel their operators to follow the instruction sent out by the manufacturers of equipment with each torch. Each size tip is so drilled that it operates at its highest heat efficiency if the pressures are used as prescribed. For each thickness of metal to be cut they tell you what size tip and pressure to use and also tell you at what speed the torch should travel. This isn't guess work on their part; they know from thousands of experiments they are always carrying on that it is right, and if *they* can cut a certain thickness with a certain tip and pressure and move the torch at a certain speed, it surely follows that you can do likewise. Our company maintains a large force of expert service operators traveling all over the country, and in all kinds of plants both large and small instructing the users of equipment to follow the instructions as to tip sizes and pressures thereby saving vast amounts of oxygen, also giving instructions as to the more modern methods. That goes for all makes and styles of oxy-actetylene welding and cutting torches on the market.

It does not take long for a hand cutting operator to get in a rut. Instead of trying to do his cutting with the least amount of oxygen, he will put into his torch a tip three or four sizes too large for the thickness to be cut, and use on oxygen pressure absolutely out of proportion to what he should use, just because it cuts easier. In a great many instances, to forcibly impress it upon his mind, we have taken his torch and actually cut metal 4 and 5 times the thickness as the metal he was cutting, using the same size tip and gas pressure as he did. It is the writer's opinion that this is the chief cause of oxygen waste and can be worked out and stopped with the proper co-operation.

Metallurgists, chemists and research men tell us that it requires a given amount of oxygen to consume or oxidize a given amount or weight of steel, and if a greater amount of oxygen is used without adding additional weight to the steel, a waste of oxygen is the result. The writer has a long laboratory report from a well-known metallurgist who claims that the most economical proportions are one cubic foot of oxygen to twenty-two hundredth pounds (.221 lbs.) of steel.

In trying to check this up, we have made some very interesting tests, covering quite a period of time with both hand cutting and machine cutting, selecting half inch steel plate to experiment on, using various size tips and pressures, and also various speeds.

Fig. 1—One Circle Being Cut and Others Laid Out for Cutting.

Fig. 2—Circles 31 in. in Diameter Cut in 9 in. Thick Steel.

Fig. 3—"A" Shows Outside Cut. "B" Inside Cut. "C" Completed Flange, and "D" Square Plates Before Cutting.

Our hand cutting test was cutting over 5,000 linear feet of ½ inch plate, covering 17 days cutting at 8 hours per day, or 136 hours. This time covers moving from one side to the other, but does not include changing of cylinders, as a 10 cylinder manifold was used, cylinders being changed before starting in the mornings. Three different size tips were used at varying pressures, but the best results were had with the smaller tip. The best day's cutting was used, which was 393 linear feet cut, 565 cubic feet of oxygen consumed. This means his best average linear feet cut per hour was 49 feet. The speed of cutting averaged 8.16 inches per minute, and oxygen consumption 1.43 cubic feet per linear foot. This is truly very remarkable hand cutting which every operator well knows.

To give you an idea as to what the human element actually means in hand operation we find that on one of these seventeen days having the same identical working conditions and the same thickness of plate to be cut, weather conditions also good, he cut as low as 258 linear feet, another day 298, another day 347, and another 360. This test conclusively proves that a hand operator cannot keep up a constant speed several days at a time.

In carrying on our machine cutting tests, we used the same size tip and lower oxygen pressures than the hand operator did, using half inch plate, each plate 12 feet long, and obtained a

*Paper read before American Welding Society, Chicago Section, Friday, May 5, 1922.

†Airco-Davis-Bournonville Co., Chicago, Ill.

speed of 18 inch per minute and oxygen consumption 1½ cubic feet to each 18 inch of cutting. The width of cut was ⅛ inch, and as one square foot of ½ inch plate weighs 20 pounds and dividing this into ⅛ inch strips we find we have 96 strips, dividing this into 20 pounds we find that we have oxidized .21 pounds of steel with each cubic foot of oxygen consumed, which is

of metal can be cut with machines, as the writer has succ- fully cut ¾-inch steel at the rate of speed of 28 inches r minute and ½-inch plate at 33 inches per minute.

With further reference to checking up the proportion- f oxygen to steel to be used in cuttinng, we also cut a 14- h billet, that is, the piece of steel of 14 inches square and e

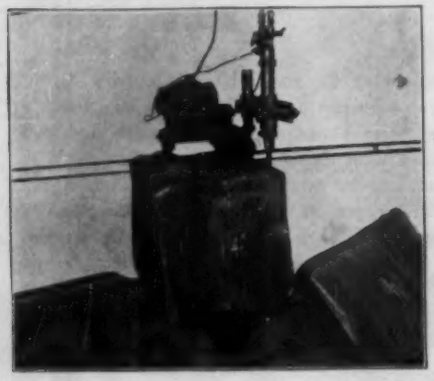

Fig. 4—14 in. Square Steel Billets Cut With Radiagraph.

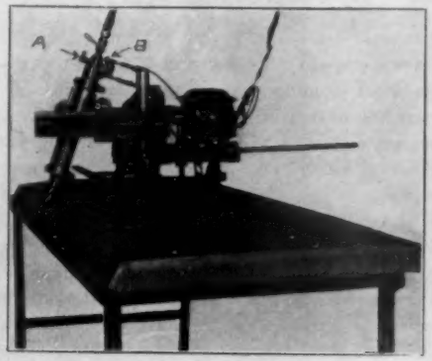

Fig. 7—Showing Method of Cutting Bevels Neatly.

Fig. 8—Plate from Which Oval, Square and Circle Were Cut.

mighty close to the figures submitted by the metallurgist. All of the machine cuts were smooth and straight. 2,500 linear feet were cut by machine.

Further checking up on this report, a large steel car plant is at the present time cutting forged steel yokes, 19 linear feet of cutting on each yoke, thickness a trifle over one inch, using the next large size tip at a speed of 12 inches per minute and oxygen consumption 2 cubic feet for each linear foot cut. Our experiments covered over a week's time using three different size tips and various pressures, before we found that the tip and pressures used at the present time of these yokes were the most economical. You will note from this that we again come very close to the proportions as outlined by this same report. These cases are only a few of the many that were carried on and we believe they conclusively prove that the most economical steel cutting is done by automatic cutting machines, cutting the waste down to a minimum. These tests do not mean that the speeds mentioned above are the highest that these thicknesses

width of kerf was ⅜ of an inch. The oxygen consumption was 100 cubic feet. The amount of steel oxidized would naturally be ⅜ of an inch wide, 14 inches long, 14 inches deep which weighs 20.4 pounds. This shows that for each cubic foot of oxygen consumed on this cut we oxidized .20 pounds of steel.

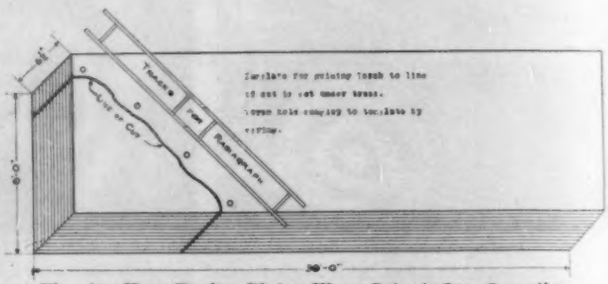

Fig. 10—How Twelve Plates Were Cut at One Operation.

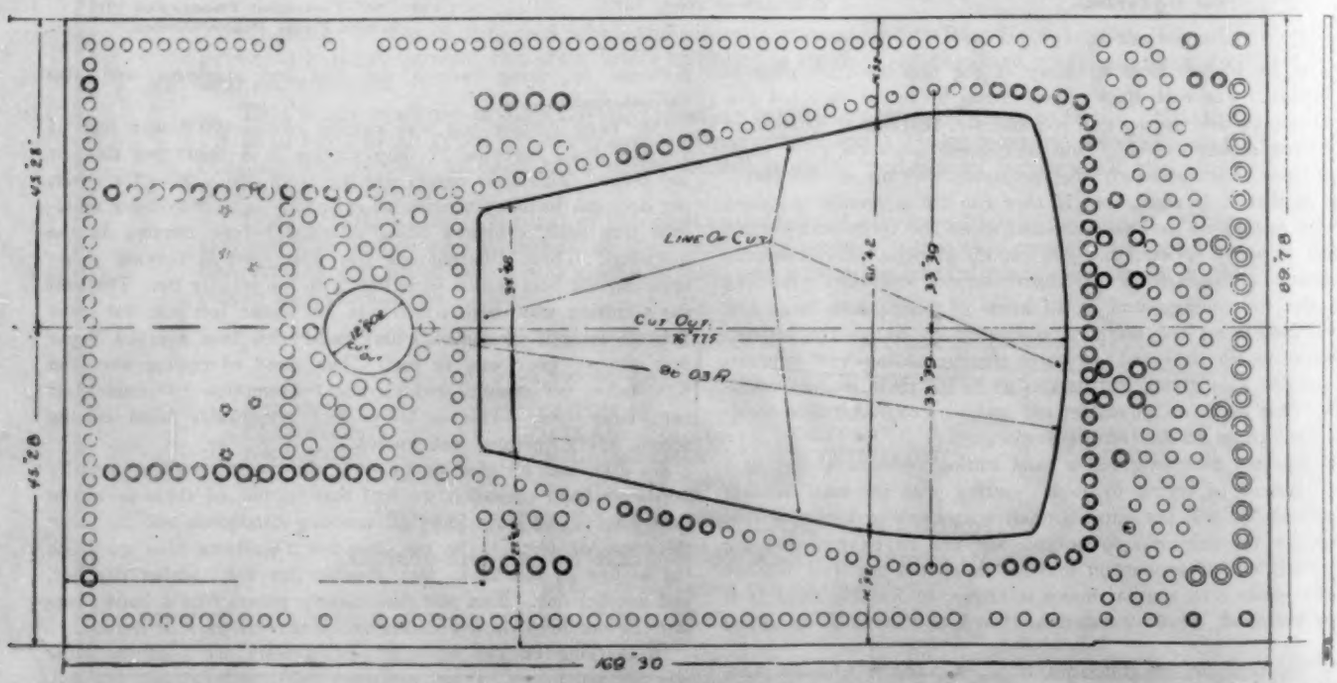

Fig. 5. Top plate for big gun carriage. Attention is directed to the accuracy required in these cuts. This is a splendid illustration of how close machine cutting can be done when the machine is properly rigged up.

The writer does not wish the impression created that these proportions are absolutely correct from the hand cutting or the machine cutting standpoint but realizes that it is a wonderful basis upon which we can all operate and if any operator, hand or machine, can better these figures, we can only say, "more power to him." Although we cannot vouch for the correctness of this report we do know from practical experience that we come mighty close to the figures outlined by it.

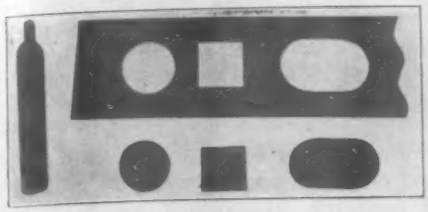

Fig. 9—Circle. Square and Oval Cut With Radiagraph.

Fig. 12—The Edges Show the Smoothness of These Cuts.

Fig. 13—Quadruple Punching and Shearing Machine for Which Housings Shown in Fig. 12 Were Cut.

That there is a vast waste of oxygen in the larger and smaller plants there is no question and engineers are at the present time co-operating with the service men to the limit to cut it down, but due to the fact that a certain amount of their work is done in an emergency, it has been hard work to bring it to their attention, unless some unusual cutting is done in their presence, to make them fully realize that the waste is going on.

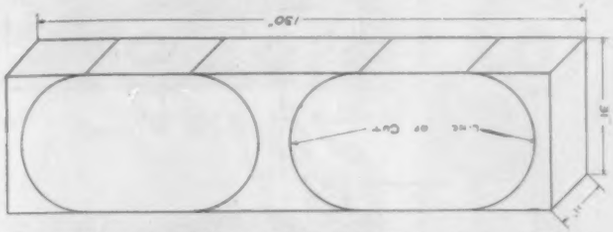

Fig. 11—This 11 in. Cut Was Made at the Rate of 4 in. a Minute.

I have in mind one case where a competitive test was held at one of the larger steel plants between three different makes of torches in which the writer took part, cutting 12-inch square billets, each operator to make nine cuts. When the demonstration was completed it was found that the difference in oxygen consumption between the three torches was about 15%. The lowest oxygen consumption on one 12-inch cut was 68 cu. ft. Their own operator then cut several billets with about the same oxygen consumption. The engineer in charge of the test asked his operator what size tip he always used and how much oxygen he consumed on cuts he had made before, and he frankly told that he had used a tip three sizes larger than the tip we had used and could only get one cut out of a 200 cu. ft. cylinder. From that day there is very little oxygen waste in that plant as the operators are being checked up continually. This is not an unusual case but it can plainly be seen that something out of the ordinary had to happen before this particular waste was stopped. This operator informed us that he had used a No. 10 tip with 185 lbs. oxygen pressure, and those of you who have had any experience with heavy cutting fully realize that this

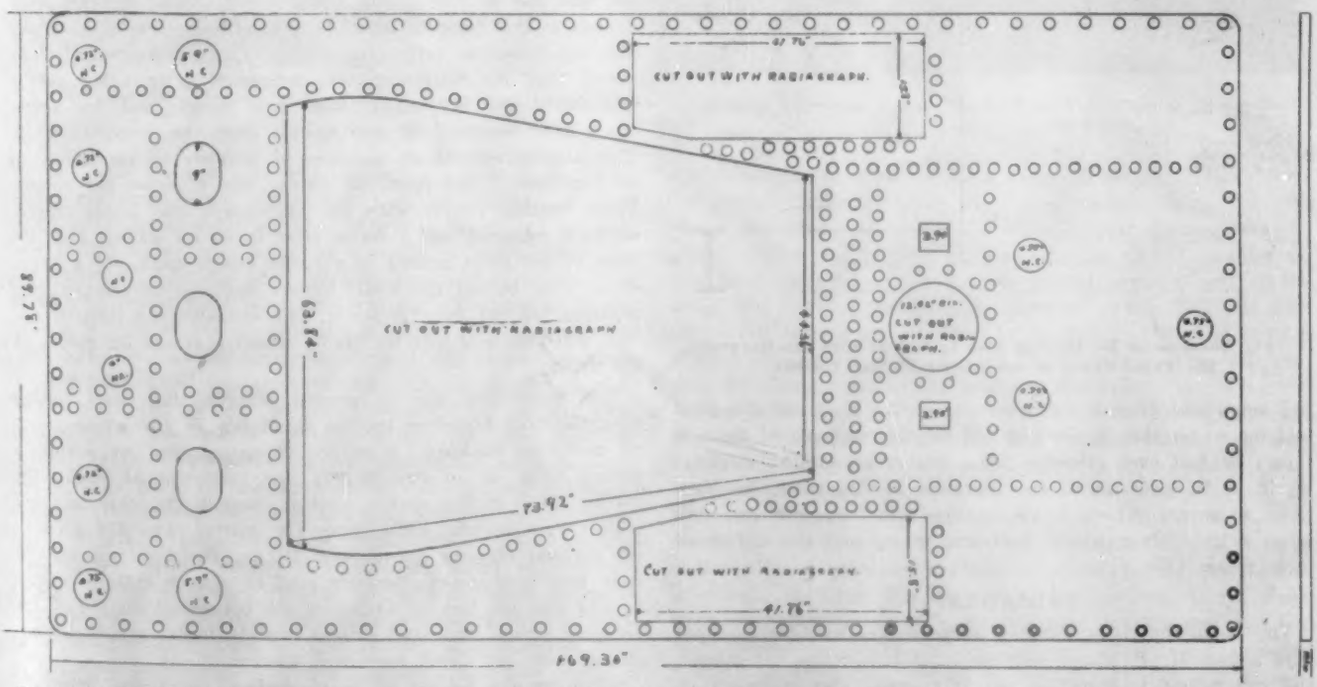

Fig. 6. Bottom plate for gun carriage. All of the squares, circles and ovals were cut with the machine. Special tracks were built for the irregular cuts in both top and bottom plates.

large pressure travelling through a narrow kerf was cooling the walls of kerf and molten oxide before it had a chance to get half way to the bottom of the billet. The test cutting was done with a No. 7 tip and 125 lbs. oxygen pressure.

It isn't a very easy job to get the officials of a large plant interested in Oxygen saving particularly those that have a great amount of emergency work, but once they do become interested there is no limit to what they will do to co-operate with you to the best of their abiliy, this is evidence the following facts of a very recent case.

We have been trying for at least six months to have one of the largest companies in this territory to form a school of instructions for the operators of their plant, and held our first

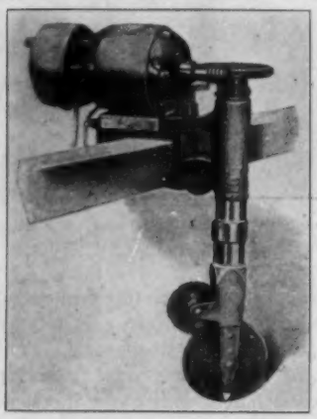

Fig. 14—Tracer Wheel, Swivel and Motor.

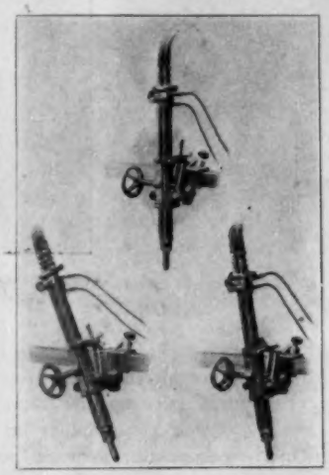

Fig. 15—Torch, Handwheel Control and Holder Which Provides a Variety of Adjustments.

class this week. There were 35 operators present and six of the highest officials attended this class. We talked on care and maintenance of equipment, explained in minute detail the construction of Regulators, Torches and Tips. This meeting lasted

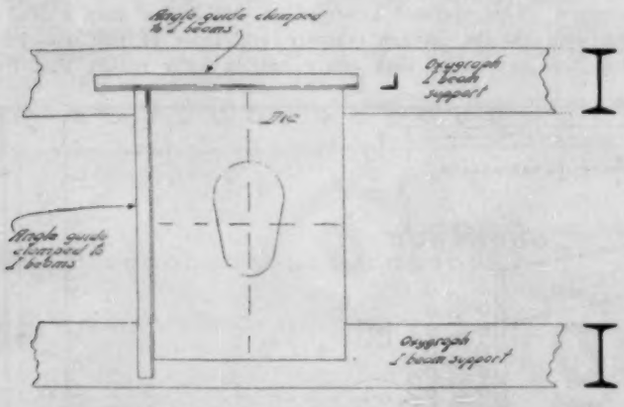

Fig. 16—Scheme for Holding Dies to Be Cut with the Oxygraph. The Three Types of Subaqueous Cutting Torches.

2½ hours and after it was over one of the heads of this plant told the writer that he thought this meeting was one of the best things he had ever attended. He also arranged that meetings would be held for all of the operators in this particular plant twice a month. There is no question that these meetings will affect a large Oxygen and Acetylene saving and also cut down their repair bills.

RADIAGRAPH

The radiagraph is a portable, motor driven machine equipped with a 1-20 H. P. Motor running 1,700 revolutions per minute, and can be set to travel or cut at twenty different speeds of from 1.5 inches per minute to 22 inches per minute, according to the thickness of the plate to be cut. The arm that holds the torch in place is so constructed that it is possible to move torch in or out, up or down, forward or backward and can also be set at any angle desired for bevelling plates. It was built for the cutting of straight lines and circles but with a little ingenuity it can be used for cutting of squares, ovals, and long irregular cuts. Photograph No. 1 shows Steel Slabs being laid out prior to cutting with the Radiagraph. These plates were 9 inches thick and the rounds to be cut were 31 inches in diameter. This little machine can be seen actually cutting one of these rounds..

There were eight linear feet of cutting to each circle. Cuts were made at a speed of 4 inches per minute or 24 minutes of actual cutting time per circle. Photograph No. 2 shows a "close-up" of the finished cuts, also the machine, and we particularly call your attention to the smoothness and accuracy of these cutting surfaces. These slabs were cut into round pieces for forging purposes.

Photograph No. 3 shows the cutting of Steel Plates 2½ inches thick and 46 inches square as shown at "D". The circles were used for flanges as shown at "C", to be gas welded to steel shells 30 inches in diameter and 11 inches long. The outside cuts marked "A" were 45 inches in diameter, and in-

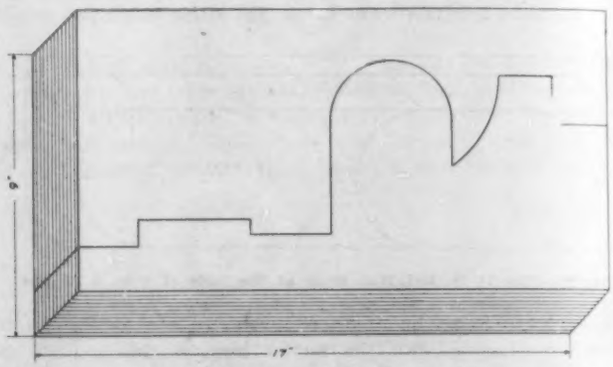

Fig. 18—Only the Bottom Plate Required Machining After This Cut Was Made.

side cut marked "B" was 30 inches in diameter. The pieces to the right marked "A" were used as flue sheets and the outside cut was the only one made. Eighty-five 1½ inch holes were drilled in this plate in which 1½ inch flues were gas welded. The specifications called for steel castings and when it was found that no machining was necessary after being cut it was found that we could make these flanges and flue sheets much more economically and quickly than the foundries could. This also eliminated all question of porosity so common with steel castings. The speed of cutting was 6 inches per minute. When cutting circles with the radiagraph the inside tractor wheel is removed and a screw pivot is set on Radius Rod, the point of the pivot resting in a center punch mark. If a larger circle is to be cut the small Radius Rod can be removed and a larger one set in. Circles of any diameter can then be cut. You will also note that the trailer wheel is set to the radius of the circle.

The impression, due to printed reports, that Steel cutting with the Oxy-Acetylene process could not be carried on above 10 inches in thickness, is surely all wrong, and we submit a picture (Fig. 4) of two mighty fine specimens of steel billet cutting 14¼ inches square, carbon content .30, that was cut with Oxy-Acetylene. The time for cutting was 6½ minutes per cut and Oxygen consumption 100 cu. ft. You will particularly note how smooth, straight, and clean each cutting surface is, and also the lack of Oxide on the bottom of the cut. This certainly proves that steel cutting over 10 inches can be accomplished with the above mentioned process.

While on the subject of heavy cutting, the writer witnessed a feat of handcutting some time ago that we believe is the most

remarkable on record. The cutting was done on 55 inch hexagonal ingots. The operator used a No. 10 tip and 195 lbs. of oxygen pressure, 7 lbs. acetylene pressure. Starting at the end of ingot the operator carried his cut along until he was cutting 37 inches clear through from top to bottom when a pocket formed on the bottom of the ingot and he was forced to stop. He then started on the opposite side of ingot and carried his cut through until he was cutting 33 inches clear through from top to bottom. The ingot was then broken by dropping a 5 ton ball on it. These measurements were then confirmed. There were four of these ingots to be cut and this operator did the same kind of cutting on the three that he djd on the first one.

Figures No. 5 and No. 6 show some of the most remarkable Radiagraph cutting ever accomplished in this country. The parts cut were Harveyized Steel Plate. The drawings and specifications called for a thickness of plate of .375 of an inch, 169.30 inches long and 89.78 inches wide, and were used for top and readily appreciate the most remarkable performance of these machines. To the casual observer watching this cutting being done, it appeared to be a very simple matter, but to those of us who had worked on this problem for weeks, it was anything but simple. Two of our troubles bear mentioning here: When the tracks were built, and sample cuts were made on ordinary plate, it was found when checking up our openings that the radius on top and bottom did not conform to the radius of track, and radius of drawing, and after quite a bit of study we remedied this by moving the torch over to the center of machine so that it was directly in the middle of tractor wheel in front, and trailer wheel in back. Then our cuts come out strictly to line. When the first Harveyized Plate was cut, it was found, to our surprise, that the cut was very ragged and rough. Then it was found that we were cutting on the Harveyized side so when we turned the next plate over and cut on opposite side. This cut was accurate and smooth.

Fig. 17—The Tracing in This Case Was Made Directly On the Table Top.

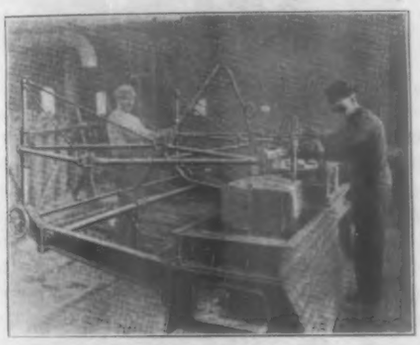

Fig. 20—Cutting Rudder Wing Arm.

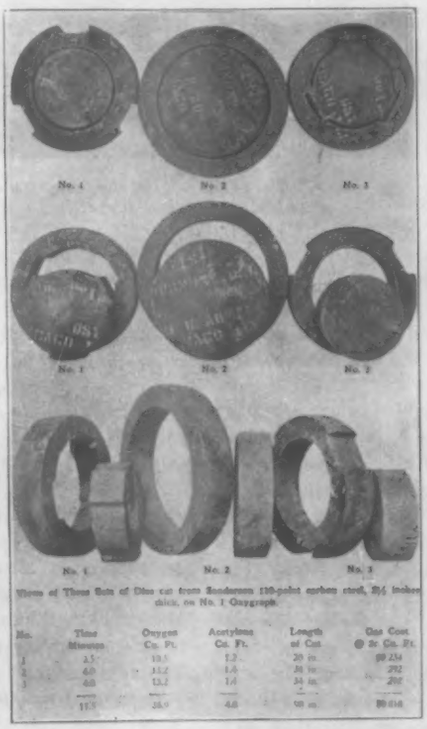

Fig. 19—Dies Cut from 110 Carbon Sanderson Steel.

Fig. 21—Cutting Completed on Rudder Arm.

Fig. 22—Making Two Cuts at Once—The Operation.

bottom plates for gun carriages supporting a 9 inch Gun. No. 5, the top plate, shows center that was cut out, also a circle 12.602 inches in diameter cut out. It will be noted that the right side of this center piece is cut to a radius of 98.03 inches, also the bottom of right end is cut to a radius of 94.22 inches. The balance of center piece is straight cutting. To accomplish this cutting it was necessary to make all cuts very accurate and straight (down) as we were only allowed .015 of an inch either way because machining after cutting was not figured on. In fact, we were told that if our machines could not cut that close to line, they would have to look further for other methods. Special tracks were constructed and bent to the same radius as the cut to be made for the three uneven sides and straight tracks used for the one straight cut for both top and bottom plates. After the tracks were bent, they were bolted in place, and cutting started. After completion of cuts the plates were allowed to cool, when they were checked up by government engineers, and then O. K.'d. Four Radiagraphs were used on this work, covering a period of close to eight months, these machines being in operation continually. All other openings in plates shown in photos were cut with the Oxy-Acetylene Process. Anyone familiar with government requirements on this class of work will

Photograph No. 7 shows the Radiagraph set on 1½ inch plate for cutting bevels. "A" is the cutting oxygen valve, and "B" shows the Electrical Switch for stopping and starting the machine. When the cutting oxygen valve is turned straight up and down, it releases the oxygen cutting pressure and at the same time forms a contact with electrical switch, "B", and both motor and cutting are started. At the finish of the cut, oxygen cutting pressure is shut off, and motor stops. You will also note the straight tracks for grinding machine.

The writer previously mentioned that the Radiagraph was primarily built for straight line and circular cutting, but with a little ingenuity could be set up to cut squares, ovals and long irregular cuts. Photo No. 8 will show how this is done. To make an irregular cut, a template can be made the same shape as the piece to be cut, and set on top of plate. The arm of torch is then allowed to swing free, and tip is held close to template with a spring. In doing this there is hardly any limit to the shape of piece you wish to cut. You will note that the machines had just finished an irregular cut, also the template and swinging arm. This method is not an economical one, but can be used in an emergency. Photo No. 9 shows the plate after cutting. In cutting ovals and squares the machine travels a complete

circle while the spring holds the torch tip to the template.

In one of the largest mills in the Central West engineers were confronted with a proposition that called for a cut to be made on ½ inch steel plates. These plates were approximately 8 ft. wide by 30 ft. long, as per Figure 10. This cut was 12 ft. in length and of sixteen different radii. After cutting they had to fit accurately other pieces for forms. Hand cutting was figured on, and it was found that too much chipping and grinding was necessary in addition; also to continue hand cutting involved the purchase of at least ten new hand cutting equipments. The engineers then turned their attention to machine cutting and purchased a Radiagraph. A template was then made exactly like the cut to be made, with the various radii, out of

Fig. 23—Cutting Two Plates at Once—The Result.

Fig. 24—Cutting Fishing Tool. Tracing Wheel As Shown on the Right.

⅛ inch black iron, 15 inches wide. A special torch was then built, which swung freely on the post of the machine, and a spring attached to post and torch to keep torch against template, so that while the Radiagraph would run on a straight track the spring would hold the torch to the template, making this cut exactly as laid out on blue prints.

In cutting one plate at a time, the set speed was 22 inches per minute and it was found that this was too slow, as these plates were to be delivered at a certain time that was fast drawing near. Four plates were then stacked up and cut one at a time. Eight plates were next stacked up, one on top of another, and cut at one time. These two cuts were so successfully made that it was decided to cut twelve plates simultaneously. After these plates were set up a bolt was set every three feet to hold plates as close together as possible. The speed of the Radiagraph was set at 12 inches per minute. Thus the cutting speed on the single ½ inch plate was 144 inches per minute or 720 feet per hour. The cut was so successfully made as to speed, smoothness, straight vertically, and so clean and to the line, that they were ready to be installed without any further labor. The balance of thes plates were cut as described. To the writers knowledge, this is the first time so many feet of half inch plate have been cut by a single cutting torch in one hour.

At this same plant, large steel slabs 31 inches and 11 inches thick were being cut by Oxy-Acetylene, as shown in Figure 11. This operation consisted of rounding off both ends and was being done with a hand operated machine, the torch moving up and down by a work screw and moved in and out to conform to radius on a bracket; one man operated a hand wheel on a screw to move torch forward; one man operated hand wheel on a bracket to move torch in and out, while a third man held and moved hose in and out as the torch moved. The length of this cut was 44 inches and time consumed in making this cut by hand operated machine was 21 minutes. This cutting was a great deal more economical than free hand cutting, and smoother, but they found it did not eliminate the machine work that was necessary after cutting.

This operation required the service of three men to make a cut. The writer questioned the necessity of a man to hold the hose, and it was explained that this was necessary, as it was impossible for the second man to move torch in or out when the hose was lying down, as the weight of the hose would bind torch on bracket. The Radiagraph was then used on this cutting, and not only did the cutting in 11½ minutes, but cut the gas consumption in half, requiring the services of but one man. The cut was so much smoother that machine work was cut down to the minimum. It will be noted from the above that this cutting was carried on at the rate of close to four inches per minute.

Photo No. 12 shows the cutting of 1½ inch plates that were used for Quadruple Punching and Shearing Presses. After these plates were cut they were machined, that is, both surfaces and all cutting edges, and it was distictly specified that all cutting was to be done .0625 inches to line. Due to the irregularity of hand cutting, also from an economical point, they were cut with the Radiagraph. The large plate in the back ground gives you a good idea as to amount of cutting done on each plate with this little machine. The small circles, "A", were cut with a

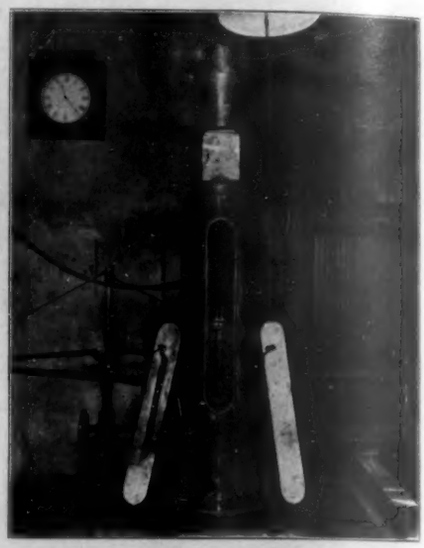

Fig. 25—Fishing Tool in Vertical Position to Show Cuts.

circular hand cutting torch similar to a compass, but all the rest of cutting was done with the Radiagraph. You will note the pilot holes in corner of squares were cut through with a hand cutting torch instead of drilling. Photo No. 13 shows these powerful machines, after the plates are assembled in operation.

The Oxygraph is a machine for operating an oxy-acetylene cutting torch, and is designed to reproduce any outline drawing, pattern or template in full or half scale, cutting to the shapes in wrought iron or steel. The No. 1-A Oxygraph reduces the copy one half in the cutting while the No. 2-A machine cuts to the same size as the drawing or template copied.

A pantagraph frame supports a machine cutting torch and the small electric motor that operates the feed gear; this comprises a knurled driving wheel or disc geared to the motor through worm and spur gearing and mounted in the fork of a swiveled vertical member. This part is free to turn in any direction required. Thus means are provided for moving the torch mechanically in any horizontal direction at a uniform rate, the speed of which may be varied within wide limits.

Tracer points are fixed to the vertical swiveled part on each side of the tracing or driving disc to assist in following the drawing. A rheostat mounted alongside of the motor adapts the voltage to the universal motor which thus can be used on 110 or 220-volt alternating or direct current. The driving disc rests on the drawing to be reproduced. When driven by the motor it rolls along slowly in the direction required carrying with it the pantagraph and torch.

The feed mechanism provides a steady and uniform motion in any horizontal direction, the direction of travel depending on the position of the feed disc with reference to the table and torch. The operator guides in cutting, by twisting the vertical standard or post this way or that as the cut proceeds, steering it around until the outline has been completely traversed.

Drawings are reproduced in cutting by the No. 1-A Oxygraph

exactly one half size, the ratio of movement of the tracing wheel and the torch tip (measured from center to center) is as one-to-two. Inasmuch as the kerf cut out with the torch is of appreciable width varying from 1/8 to 1/4 inch or more, it is necessary to make allowance for the kerf when cutting.

Allowance for the kerf may be made by adjusting the pointers so that the distance between the points and the center of the tracing wheel is equal to the width of the kerf. The preferable method is to make the allowance on the drawing, however. Track lines are traced on the drawing inside or outside of the pattern at the required distance to allow for the kerf. The tracing wheel is run directly on the line and the pointer is ignored except when turning a corner. It is then used to indicate when the point is reached at which the swivel should turn. When the Oxygraph is used for production cutting, pencil drawing may be replaced by metal templates that serve as guides to the feed disc, and thus make it possible to reproduce the required shape exactly and as many times as desired. The construction of these templates depends on the shape desired and the allowable cost. When many pieces of the same shape are to be cut the cost of the template will be distributed over the whole lot and a construction may be advisable that would not be used where only a few pieces are to be cut.

The simplest form of template is a grooved track for straight line cutting. This guide may be made from a strip of cold rolled steel, say 2 inches wide, ½ inch thick in which a vee groove ⅛ inch deep and about 1/4 wide had been planed in the middle. Such a guide is indispensable for cutting off and other miscellaneous straight line cutting where a smooth effect is desired.

When the Oxygraph is required to cut circles or circular arcs it may be set up with the radius attachement provided, which makes the tracer wheel follow the arc automatically. The center point on the radius rod may be adjusted to any length of radius within limits. The radius rod is inserted in the tracer wheel bearing in place of the regular short pivot and thus the wheel is held tangent to the curve.

The work table of the No. 1-A Oxygraph is 36 inches square and the area covered by the torch, following the largest drawing spread on the table, is 18 inches square. The largest rectangular cuts are made on the diagonal from opposite corners. Thus, a shape 2⅛ inches wide, 23 inches long can be cut using a drawing outline 4¼ inches wide and 46 inches long to guide the tracer wheel. (See Fig. 11.) However, larger designs can be cut by extending the table, using a drawing board to suit.

The Oxygraph has a wide application and many uses in tool shops, manufacturing plants, locomotive works, shipyards, drop forging concerns and wherever tools, dies, forgings and shapes are produced. The cutting action of the torch flame is smooth and rapid, and as any shape can be cut, it is comparable to a metal band saw of great power, following straight lines, curves and angles acute or obtuse. Thin sections are cut more rapidly, of course.

Punches, dies, stripper plates and bolsters are cut in tool shops with the Oxygraph with resultant large savings of time and cost. The usual practice in making a cutting or trimming a die is to plane the block on the top and bottom, bevel the sides, lay out and drill holes to the line, cut out the walls between the drilled holes with a broach or drift, and finish with hammer, chisel and file, or by backing out with a shaper or slotter. Almost invariably a die made in this manner warps and twists in the process which requires either replaning on the bottom or shimming up in the bolster. The removal of the mass of steel in the center of the die relieves internal stress and lets the block warp out of shape. Not so when the rough die block is cut out on the Oxygraph. All troubles of this sort are eliminated and the danger of cracking in hardening is reduced to a minimum. The rough die block is preheated and cut before planing, using a paper drawing to guide the tracer wheel.

When the opening has been cut, the die (still hot) is placed in an annealing box, covered and left to cool. When cold it is planed and finished in the usual manner with the assurance that internal stresses have been relieved. Finishing the die to precise dimensions and backing out for clearance is done in the usual manned. Not only is the Oxygraph useful for blocking out dies but it may be used also to cut the stripper plates and bolsters.

Photograph No. 14 shows a close-up view of the tracer wheel swivel and variable speed universal motor. The larger wheel follows over the tracing and you will note the guide coming down through the large wheel for turning at corners.

Photograph No. 15 shows the torch, hand-wheel control, and holder which provides for sideways and transverse angular adjustments. These adjustments can only be used on straight line cutting and cannot be used for circular or irregular cutting.

In the cutting of die steel, we have found through long experience that will all dies with a Carbon content above .75 preheating before cutting is absolutely necessary to insure a smooth accurate cut. All die steels below this carbon content can be cut without preheating. This necessitates the taking of the die away from the jig after it is lined up, preheated to about 750° F. or over and then it is put back in jig and cut. On Photo No. 16 you will note that two 6 inch "I" Beams are set on the frame of the machine, to support the die. Two 1½ Angles are then clamped to the I-beams to hold die in place. The shape to be cut is scribed on die and a little off the line of cut a 1/4 inch hole is drilled for starting. Two straight lines are also scribed, both ways, through the middle of die which enables the operator to set his drawing in the correct position. As this die is set up in jig when cold, then taken off and heated and placed back on jig ready to be cut, it is necessary to make provisions for the difference in size of die due to expansion caused by preheating. To overcome this a few strips of newspapers are placed between the angle irons and die when it is first set up, and the die is cold. When the piece to be cut is taken off the machine to be heated, the pieces of paper are removed from jig and hot die put back again to be cut. Experience quickly teaches us how much allowance it is necessary to make for various sizes and thicknesses of dies.

Photo No. 17 shows the cutting of twelve pieces of ¼ inch steel plates, one piece being laid upon the other, at the same time, on the 1-A Oxygraph. You will note the drawing is laid out on the tracing table and is twice the size as the pieces to be cut. Photo No. 18 shows a line drawing of this cut and will give a much better idea of the irregular forms that can be cut on this type of machine. These pieces were used for wheelbarrow construction.

Photo No. 19 shows some very remarkable die cutting that was done on the 1-A Oxygraph. The metal was 110 point Sanderson Steel each piece 2½ inches thick, and you can see how smooth and clean these dies were cut. The figures below give an idea as to the speed and gas consumption.

The No. 2 Oxygraph, designed for heavy forge work and large plates has two pantagraphs connected by a horizontal square tubular bar in front that holds the torch or torches, also the driving motor and feed gear. Photo No. 20 shows a rudder wing arm, 10 inches thick set up on machine. The operator is just starting his cut. Photo No. 21 shows the completed cut and the crop end can be seen lying at bottom of Machine frame opening. These photographs clearly bring to our attention that nothing within limits is too light or too heavy to cut on these machines where accuracy in cutting is the main factor.

Photo No. 22 shows the cutting of quadruple punch machine plates that were previously cut with the Radiagraph. These plates are 1½ inches thick and total amount of linear feet of cutting is 15, and were cut at the speed of 13 inches per minute. This also shows how the No. 2 Oxygraph increases production without adding any additional labor cost, as the two plates were being cut at the same time with one operator. You

(*Continued on page* 46.)

ARC WELDED STEEL BUILDING

Savings in Time, Labor and Material—Methods of Making Joints—Welded Joints Pass Tests

By B. C. Tracey *

A RECENT and wholly successful application of arc welding to the construction of a structural steel building, has, in addition to proving the practicality of the process when used on a large scale, furnished interesting figures showing the comparative economy between arc welding and riveting as a construction method. The building in question, the framework of which is completed, is located in the Schenectady Plant of the General Electric Company, its dimensions being 40x40x40 feet, and 34,339 pounds of structural steel being used in its construction.

Among the savings mentioned, by far the most important are those of time, labor and material. While it would be difficult to make the first two, as effected in this case, the arbitrary basis of a statement as to just what savings can be expected on all similar jobs, owing to the purely local conditions under which the work was done, they are sufficient to prove that the economy in any case would be great enough to warrant serious consideration. As to the third factor, material, the economy will be in direct proportion to the size of the building to be erected. With regard to time alone, it has been estimated that, in the case of this particular building, if riveted construction has been used, it would have been necessary to mark and punch 4500 rivet holes in the shop, and to drive some 1800 rivets in the field. As a matter of fact, the time involved in punching was absolutely eliminated, and that in marking greatly reduced. The pieces were simply cut to length, and fabricated as far as possible in the shop, as shown in Fig. 1.

Fig. 1. The Pieces Were Cut to Length and Assembled in the Shop

The saving in labor was correspondingly great. The ordinary gang for riveting consists of at least four men, the heater and thrower, the catcher and sticker, the bucker or holder on, and the driver. The welding gang on the other hand may consist of one man, although it is desirable to employ a welder and one helper in fabricating the parts before tacking. The difference in labor charges between these gangs is too obvious to require comment. Without regard to the time that it might have taken to put up the building with rivets, it actually took 186 welding hours, including the fabrication in the shop, to erect it with the electric arc. In material a saving was made which is represented in weight and cost by the difference between those of 1800 ¾ inch rivets, with a weight of over 1,000 pounds, that would have been necessary, and those of 150 pounds of mild steel welding wire, that was actually used.

Figs. 2 and 3 give a good idea of both the details of construction and the general appearance of the framework as completed. The bracket shown in Fig. 2 is one of eight which are used to support the runway for a five ton crane. This runway

Fig. 2. A "Close-Up" of the Details of the Construction

is visible just over the roof of the building in the background of Fig. 3. The bracket consists of two gusset extensions welded to the main support, and a cross plate welded to angle irons, which are in turn welded to the flat surfaces of the gussets. The illustration also shows the method of fastening the bracing structure to the main column.

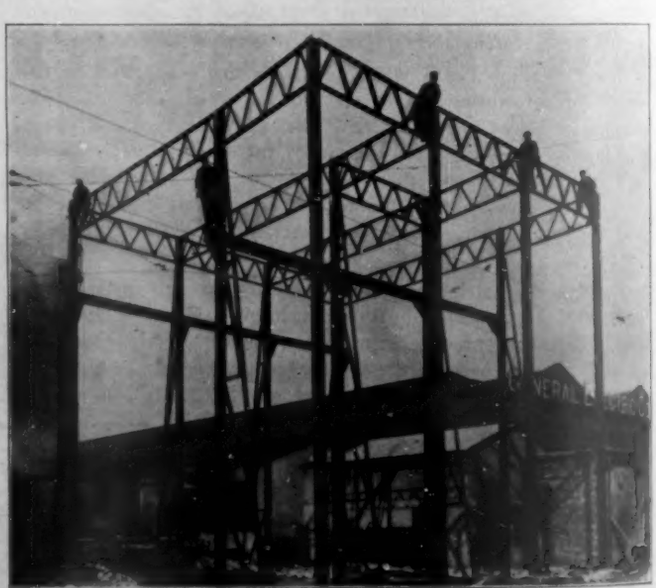

Fig. 3. General Appearance of Completed Framework

*Power and Mining Engineering Department, General Electric Company.

The construction of this building was only attempted after numerous tests had been made, and the practicability of the process determined by the observation of the results obtained in the construction of similar projects on a smaller scale. The first of the latter was the construction of a bridge joining two sections of one of the buildings of the plant, and is shown in Fig. 4. This illustration is an interior view, and gives a clear conception of the method used in connecting the gusset plates, angles, roof

Fig. 4. Method of Constructing Gussett Plates and Arch Post

trusses, and framing angles. It can be plainly seen that short fillet welds were used throughout the complete assembly instead of a continuous weld. Previous tests had determined that a continuous fillet weld was not necessary for the strength required in this construction.

The second undertaking consisted in the erection of a crane runway in one of the factory buildings. The majority of the parts were fabricated in another shop, and brought to the place of installation, where they were assembled. This was accomplished so as to occasion no interference with the production work carried on in that building. The crane has been in daily operation on the runway for the last six months without trouble of any kind being experienced.

In the meantime a number of tests had been carried on to ascertain the value of the stresses that could be safely applied to welded joints. The engineers in charge were sufficiently satisfied with the result of these tests, and with the success of the structures mentioned above, to try out the process on the larger scale represented by the welded building. Its progress has been such as to justify the prediction that the future holds great

Fig. 5. Fabricating the Structural Iron Parts

possibilities for the erection of structural steel parts by the process of electric arc welding.

In conclusion it should be appreciated that in order to get the best results in this class of work, not only should the services of competent welders be secured, but the metal itself should be rendered free from rust, oil, or surface scale. Any one of these, if present will tend to make the arc unstable, as well as introducing into the deposited metal a portion of oxide, which will create a weakened section through the welded portion. Too much care cannot be exercised in the preparation of the parts to be welded, since this can be very easily done with a roughing tool, a small portable sand blast, or a stiff wire brush. Fig. 5 shows an operator welding connections in the shop previous to their being sent to the point of erection.

The Beefsteak Dinner Which Was a Feature of the American Welding Society Three Day Program.

WELDING AND CUTTING APPARATUS

The Bureau of Standards states in Report No. 200, page 94:

"With blowpipes furnishing THE ACETYLENE UNDER A HIGHER PRESSURE it is therefore evident that the tendency to produce flash backs is minimized if not entirely suppressed."

REGO Pressure Chart

Tip No.	Pounds Acetylene Pressure	Pounds Oxygen Pressure
L-1	2	1¾
L-2	2¼	2
L-3	2½	2¼
L-4	3	2½
L-5	4½	3
L-6	5	4
L-7	5¼	4½
L-8	6	5
L-9	8	6½
L-10	9	7½

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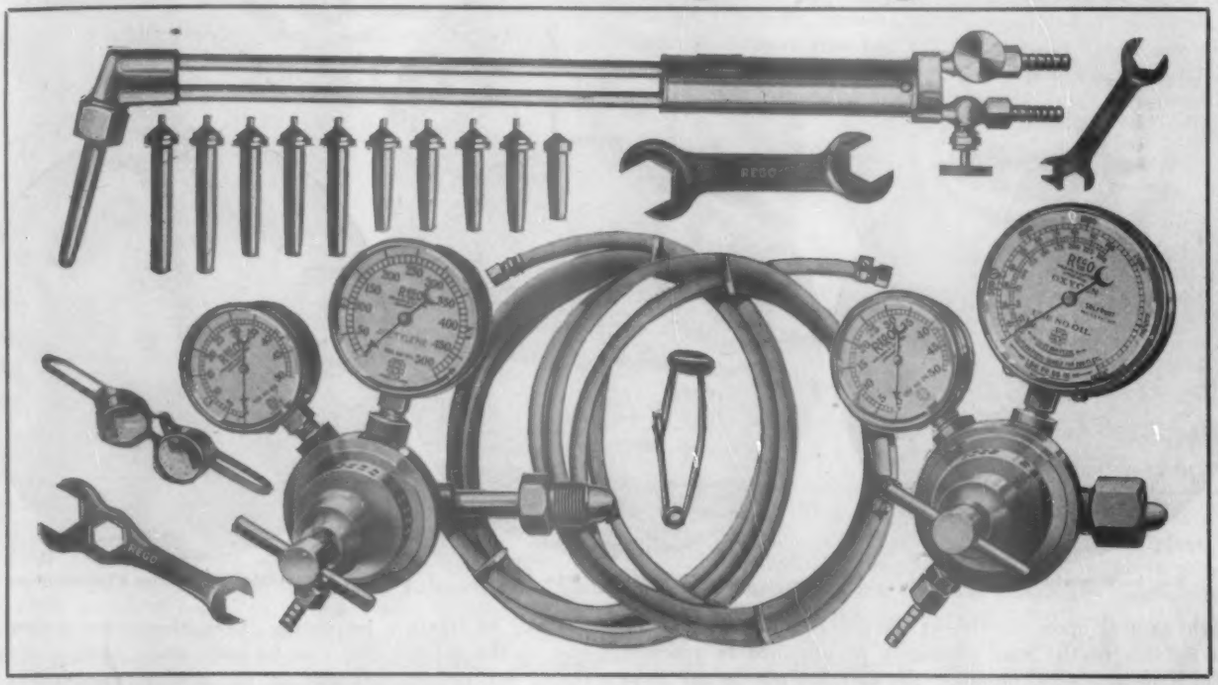

The REGO L combination Welding-Cutting Torch is **THE** torch for general welding and repair shops. This torch is designed for any range of welding work. There is no extra weight of high pressure cutting valve or cumbersome attachments to burden the operator. Changing the welding tip to a cutting tip changes the torch from a welding to a cutting torch. The high pressure cutting jet is regulated **IN THE TIP.**

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THE SCIENTIFIC SIDE OF WELDING*

Comparison of Micro-Structure of Iron and Steel With Micro-Structure of Welded Metal

By E. Atkins†

IN INTRODUCING the subject it may be said that the operation of welding in some form or other has now become one of the most important and universal of all metallurgical processes, and by virtue of its great usefulness should command the most thought and intelligence that can be brought to bear upon experiment and investigation so that the most reliable results may ultimately be obtained in practice.

Whilst to the casual onlooker the carrying out of any form of fusion welding seems to be a very simple process, to those who have had experience and know, it is not an easy matter to make any form of welded joint to give the best possible result. Good welders, indeed, are sometimes puzzled with the kind of results they obtain, simply because some factor which is outside their control may creep in and entirely upset their calculations. There are so many things which affect the making of a good welded joint, that it is not surprising that results are so variable. It is, therefore, essential that careful scientific investigation should be regularly carried on so as to put operators in the way of guarding against all possible defects in their work. Apart from physical deformation the most common form of defects found in nearly all kinds of welds are:—low tensile strength and poor elongation. These mechanical defects result either in brittleness or indifferent bending qualities of the joint, and offer small resistance to fracture by shock. Low elongation is certainly one of the defects that can be seen when joints are being tested for tensile strength in the testing machine, as the amount of plastic stretch at the joint portion of the plate is usually very small.

Fig. 1—Wrought Iron Unetched.

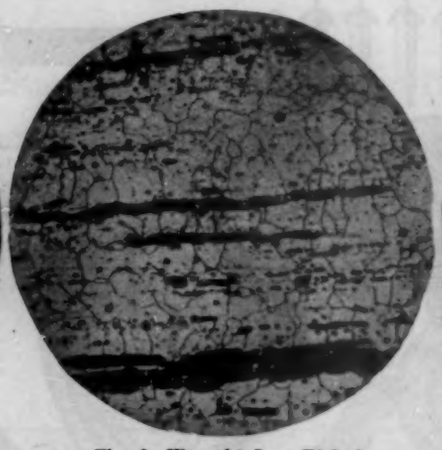

Fig. 2—Wrought Iron Etched.

Fig. 3—Acetylene Weld on Common Iron Bar.

Whilst speaking of the defects in welded joints it should not for a single moment be thought that any of the various systems of welding in vogue are generally in default, for all of them in one way or another do very good work. A comparison of the different methods of welding is very difficult to make either to the advantage or disadvantage of any particular system. One thing, however, is quite certain, that each system under certain conditions has its own useful sphere of operation.

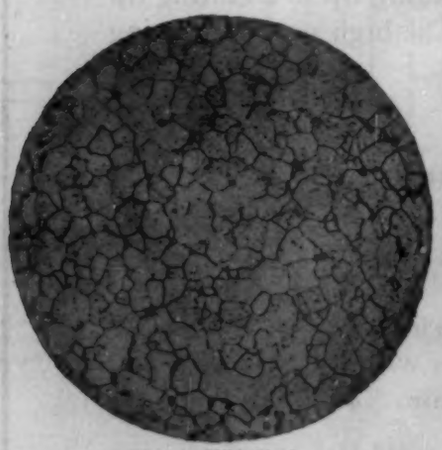

Fig. 4—Mild Steel.

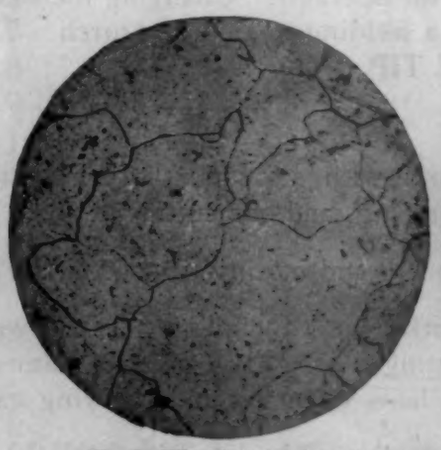

Fig. 5—Mild Steel Overheated.

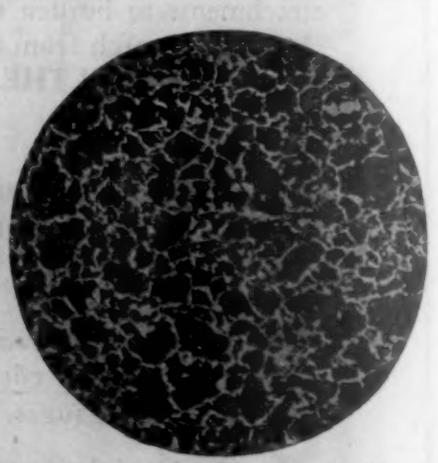

Fig. 6—Steel 55 Per Cent Carbon.

Referring again to the previously mentioned mechanical defects it may be said that whilst these are well-known, the cause and cure of same are not so easy to fathom, and it is in this direction that it is necessary to make very careful in-

*Lecture delivered at a general meeting of the British Acetylene and Welding Association, on Thursday, September 22, 1921.

†General Works Manager, Messrs Rylands Brothers, Ltd., Warrington.

vestigation. One of the best ways by which information can be obtained relating to welded joints is to have a large number of experimental welds made by ordinary methods of working and to subject these to what may be called a process of anatomising by the use of the microscope supplemented by chemical analysis and physical tests. This method has been adopted by myself for some years in connection with all kinds of welding processes and much information has been obtained which explains the cause of defective welds.

Fig. 7—Pearlite Structure in Steel Magnification 1,000 Dia.

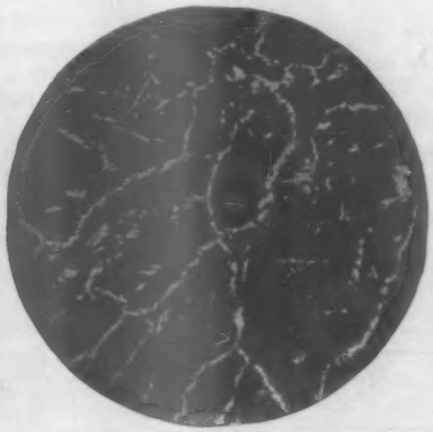

Fig. 8—Annealed Steel 1.4 Per Cent Carbon.

Fig. 9—Quickly Cooled Steel 1.4 Per Cent Carbon.

Micro-Structure of Iron and Steel

Before showing any of the defects which are set up in joints, it will, perhaps, be as well briefly to explain the kind of micro. structure found in wrought iron, mild steel, etc., from which it will then be possible to make a comparison with a welded joint structure of the same material. It should be particularly remembered that the structure of a metal and its physical properties not only depends upon its chemical composition, but also upon the kind of heat treatment it receives and the amount of work that has been done upon it either in rolling or hammering, and that the particular structure engendered through this treatment is often entirely upset when the metal passes through any form of fusion welding. Hence, this explains how difficult it is to make a welded joint in which the filled-in material should not only have the same chemical composition as the plate welded, but also have the same physical properties.

The micro. structure of a piece of wrought iron is shown in Fig. 1. To obtain this the surface of the iron has been highly polished and the photograph taken to a magnification of 100 diameters. (Before passing on it will be as well to remember that the following microphotographs, except where otherwise stated, are all to a magnification of 100 diameters.)

The grey bands seen in Fig. 1 are the well-known slag threads that are always found in wrought iron. Fig. 2 shows the structure of a piece of wrought iron after it has been polished and etched with dilute picric acid. The etching, it will be noticed, has not only brought up the grain structure of the wrought iron, but also shows that the slag has a compound structure. The junction of a good acetylene weld made in wrought iron is shown in Fig. 3, in which it will be seen that there has been complete fusion, the most noticeable feature being that the slag threads have been balled up into small globules in passing through the welding state. The structure of a mild steel is shown in Fig. 4. Upon examination of this it will be noticed that in between some of the grain boundaries there are small dark areas, this being what is known as the pearlitic structure and containing the carbon. Fig. 5 is of identically the same steel, which has been somewhat overheated causing enormous grain growth resulting in the material being brittle and showing a coarse crystalline fracture.

Fig. 10—.50 Per Cent Carbon Steel As Cast.

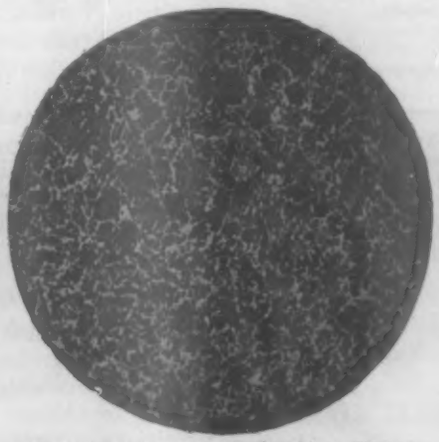

Fig. 11—.50 Per Cent Carbon Steel, Forged.

Fig. 12—Fire Weld in Mild Steel and Wrought Iron.

The structure shown in Fig. 6 is of .55 per cent carbon steel, and in this it will be noticed that the black areas of pearlite have considerably increased, the white areas of iron, or ferrite as it is called, now being reduced to a network structure.

It will be interesting to observe that the pearlite has a distinct structure of its own, this being shown to the higher

(*Continued on page* 32.)

The Welding Engineer

Reg. U. S. Pat. Office.

Published on the 17th of Each Month by

THE WELDING ENGINEER PUBLISHING CO.,

608 S. Dearborn St., Chicago, Ill.

Telephone Wabash 7134.

L. B. Mackenzie.....President and Editor
H. S. Card.....Associate Editor
R. L. Miles.....Associate Editor

Subscription payable in advance and postage free.
United States and possessions and Canada.....$3 a year
Foreign Countries ..... 4.00 a year
Single copy, domestic .....25 cents
Single copy, foreign .....30 cents

Entered as second-class matter January 20, 1916, at the postoffice at Chicago, Illinois, under the act of March 3, 1879.

The Welding Engineer is a member of the Audit Bureau of Circulations and of the Associated Business Papers, Inc.

Last Advertising forms close at 8:00 a. m. on the 15th. To show proof for correction copy must be received at an earlier date and allowances should be made for delay to mails.

The Welding Engineer does not publish in its news or advertising columns any matter that deals with or refers to either personal or legal controversies.

EASTERN REPRESENTATIVES
Ben-Hill Co., 14-16 Vanderwater St., New York
Telephone: Beekman 3415—3416

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Teach Welding to the Superintendent

TWO instances related at a recent gathering of weld will serve to illustrate the lack of welding knowle on the part of foremen and superintendents and the need educating them to a proper understanding of the probl which confront their welders. In one instance a welder cal a service man to one side and said, "You've got to make boss understand that welding is not bricklaying. Just cause I made a good weld at a good rate yesterday on so test pieces, he expects me to make the same speed in a sc old boiler job where I have to work in a cramped position. can do this job all right, but I want my weld to stand up and it won't stand up if I do it half as fast as he expects me to work." Here was an honest workman handicapped by the ignorance of his employer. Another case occurred in a railroad repair shop. A huge casting was to be repaired and the welder knew the job called for two good men. His foreman objected, simply because he couldn't understand that the nature of the job required the extra help. But the foreman made another bad break. He called his man off the job during the noon hour and allowed the weld to cool before it was finished. These conditions will prevail until superintendents and foremen become fully informed on welding subjects. Salesmen and service men can help their game by putting in a good word for the welder when talking to his employer, for the judgment of the experienced welder is entitled to considerable respect.

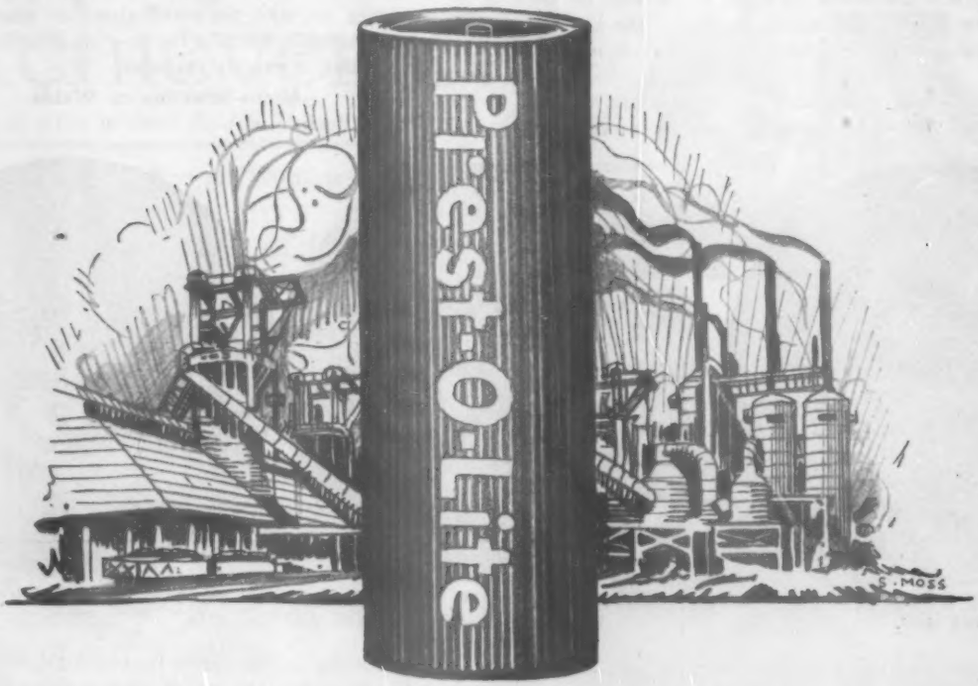
Seeing Ourselves as Others See Us

A CURRENT number of our French contemporary, the *Revue de la Sondure Autogene*, carries a very interesting article entitled, "Humor in Autogenous Welding." The editor notes that the American trade journals devoted to welding make a practice of livening up their pages by the use of cartoons and rumorous stories, interspersing bits of humor and clever drawings with the technical and practical data pertaining to the industry. He compliments our conrtibutors and artists on their ability to make their "human" touches so pointed. Further mention is also made of the fact that this spirit is carried into the advertising pages, so that trade disputes are handled in a good natured, rather than a vicious, manner. Our manufacturers are complimented on the gentlemanly way they handle competition. We hope that our contemporary's praise is as well deserved as it is sincere. And we thank our good friend for his frank and cordial comment on the welding industry in America.

One Way to Interest the Man Higher Up

IN Mr. Maeurer's paper on mechanical cutting, which appears in this issue, mention is made of a school for welders and cutters which has been put into operation in a large plant near Chicago. This "school" consists of a series of fortnightly lectures given to all the operators who can be assembled for the purpose. The purpose of the lectures is to concentrate the attention of the men on important general principles which are involved in welding and cutting. The observance of these principles has a two-fold result: First, better workmanship; and second, more economical operation. Plant managers and superintendents were interested in the school idea and a number of them turned out to see what the first lesson would be like, and how it would be received by the men. Needless to say, it pleased them; it would please any group of practical men. They praised the idea and valunteered to attend all future lectures. There is no doubt about the result. Welding will show steady improvement in such a plant and when mistakes are made the managers will send out for information on what went wrong, instead of putting all the blame on the process.

Read on this page, from issue to issue, a description of the features which have made Prest-O-Lite a national institution



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DISSOLVED ACETYLENE

THE SCIENTIFIC SIDE OF WELDING

(*Continued from page 29*)

magification of 1,000 diameters in Fig. 7. It will be seen that the structure is of a laminated character, the alternate layers being respectively composed of carbide of iron and ferrite.

The amount of carbon in pearlite is always .89 per cent and this is a fact which should be borne in mind in the examination of the structures of the different steels, as when in the normal or annealed condition the kind of structure will indicate the carbon point of the steel.

Fig. 13—Fire Weld in Medium Carbon and Mild Steel. Fig. 15—Good Acetylene Weld in Wrought Iron. Fig. 16—Unhammered Acetylene Weld in Mild Steel.

To exhibit the structural formation of a steel that contains more than .89 per cent of carbon, the microphotograph Fig. 8 has been prepared, the dark areas in this showing the pearlitic formation, and the white network in this case being of the hard carbide of iron. This steel when quickly cooled

Fig. 14.

gives a structure which is entirely different and this is shown in Fig. 9, in which the hard brittle structure of martensite is seen. This is the characteristic structure which is often engendered in very quickly cooled welds of high carbon, which will inevitably result in fracture if not properly annealed.

It ought to be well-known that the resulting structure of a steel and its corresponding physical properties will depend in a large measure upon the amount of work that is done upon the steel in the hot state. Thus in Fig. 10 a microphotograph of a .50 per cent carbon steel is shown just as cast into a small ingot. In this photograph it will be seen that the grains are very large, there being only three or four covering the surface photographed.. The structure of the same steel after being carefully forged down and finished at a dull red is shown in Fig. 11. In this it will be noticed that the grain growth has been such that the area marked out by one of the large grains in Fig. 10 is now covered by about 100 grains in Fig. 11, with the result that this material is considerably tougher than when in the cast state, although its chemical composition is exactly the same.

Micro-Structure of Welds

As we are dealing with all kinds of welds it will not be out of place to bring in the old-fashioned blacksmith's fire weld, and to illustrate this the micro. photographs Figs. 12 and 13 have been prepared. Fig 12 shows the junction of wrought iron welded to mild steel, whilst Fig. 13 shows the junction in the welding of mild steel and medium carbon steel. In both of these welds it will be observed that there is complete fusion, the result being, on testing, that each of them gave 100 per cent efficiency. Fire welding, like, indeed, almost any other form of welding, depends very largely upon the quality of the blacksmith, and whilst it has been said that a fire weld gives a strength of 80 per cent of the solid bar, it is never safe to fix any percentage without intimate knowledge of the character of the particular blacksmith's work.

The junction of metals in a good electric arc weld is shown in Fig. 14 in which it will be observed there is complete fusion of the joint; this is also seen in the good acetylene weld in wrought iron in Fig. 15. The last two again giving an efficiency of 100 per cent. Fig. 16 is of good acetylene weld in mild steel which shows complete fusion at the junction, but rather large grain on account of not being hammered.

(*To be continued*)

WELDING SUPERHEATER FLUES IN LOCOMOTIVE FIRE BOXES WITHOUT THE COPPER FERRULE

By R. W. Gardner

In the boiler shop of the St. Louis and Southwestern Railway at Pine Bluff, Arkansas, superheater flues are welded in locomotive fire boxes without the use of the copper ferrule. The expanding of the flue is also done away with. The process used in the shop is interesting and somewhat after the following simple fashion:

The flue holes are first countersunk to about a 45 degree angle. The flues are then inserted and centered in the hole by the use of a steel wedge. They are left to project about $\frac{3}{16}$ of an inch from the sheet line. The seam is then started at the bottom and traced around the tube to the top on one side. The welding device is then carried back to the bottom and the seam traced on the opposite side. When completed, they should be about $\frac{1}{8}$ of an inch outside of the sheet. The small flues and coppers between the supers should be left out until the welding is done.

According to authorities in the St. L. & S. W. shop, the process is quite successful. They report that several sets have already overrun their rated mileage and have given no trouble whatsoever.

Achievement

Achievement—in terms of service to you—is here represented by types of G-E Arc Welding Equipment.

From the first sets for hand welding operations to the new type of Portable Semi-Automatic Arc Welder—the General Electric Company has been a pioneer in the design and manufacture of equipment which gives to Industry the broadest uses of arc welding.

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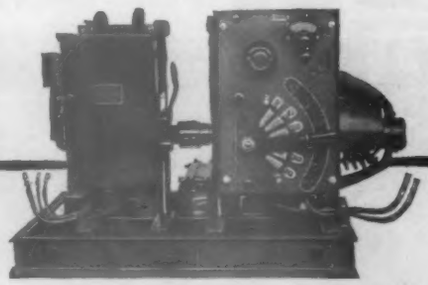
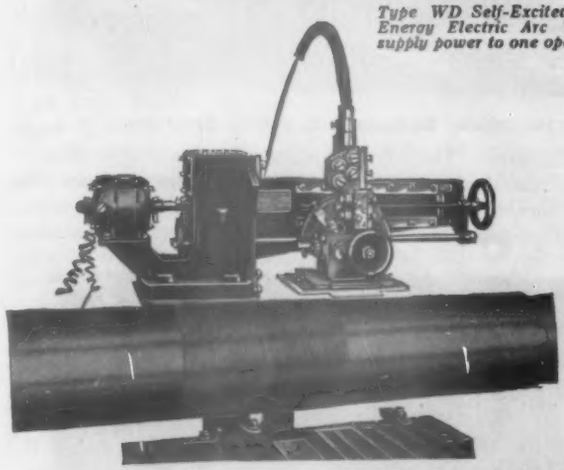


Type WD Self-Excited Constant Energy Electric Arc Welder to supply power to one operator.



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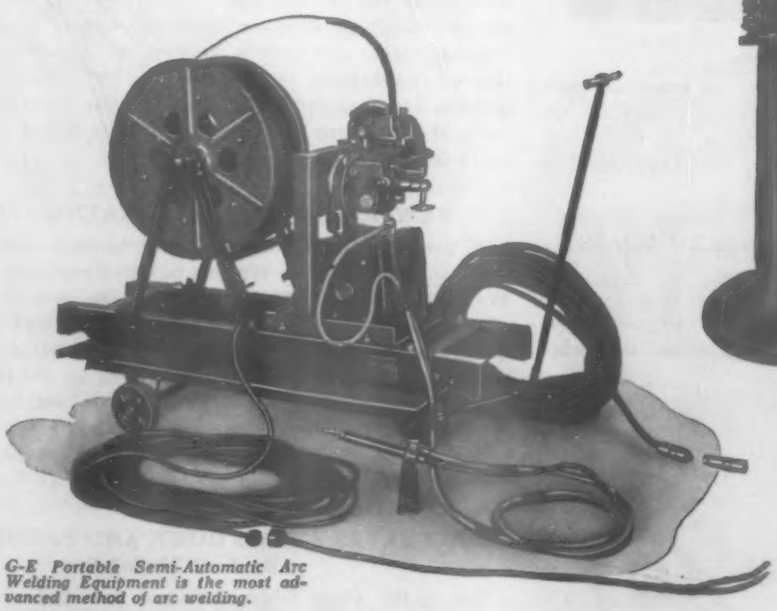

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FIRE TRUCKS EQUIPPED WITH CUTTING OUTFIT

Recently the Indianapolis Fire Department have equipped a number of their fire trucks with cutting equipment and cylinders containing oxygen and hydrogen gas, as furnished by the Indiana

Fire Trucks Equipped With Cutting Apparatus.

Oxygen Company. The oxygen-hydrogen cutting equipment will be used to cut down steel bars and grating from windows and floors on burning buildings, to aid the firemen with their work, before the conflagration has made much headway. In rescuing

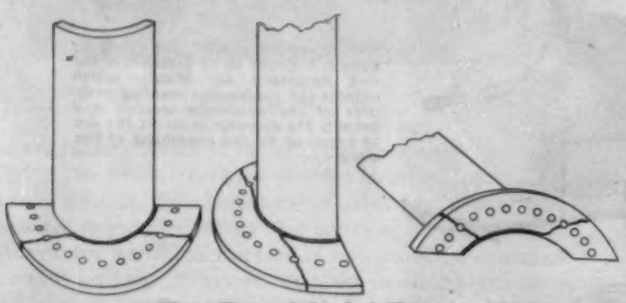
Firemen Cutting Grate Bars.

human lives, the cutting torch has played an important part. The Coroner's Jury in deciding the contributing causes for the Knickerbocker Theatre disaster in Washington, D. C., recommended among other things, "That the City Fire Department be equipped with cutting outfits."

METALLIC ARC RESTORES CRACKED BRASS FLANGE

By L. J. Cullen

A stern bearing on the S. S. Sandy Hook belonging to the Central Railroad of New Jersey was cracked across the flange



Three Views of Cracked Flange.

for a distance of about 12 inches straight across and an additional Arcuate crack of about 5 inches. The crack was not all the way through but gave way immediately upon receiving the impacts that occurred while the groove was being chipped preparatory to welding. The metal was of brass and bulky in size. After the parts had broken apart, it was necessary to make a double bevel in order to make a successful weld. This was done and the welding performed.

A. D. C. electric arc welder was used with the electrode positive and the carbon arc switch thrown in. Instead of using the carbon electrode, a filler rod of $\frac{3}{32}$ inch manganese bronze was used. A 60 volt, 150 ampere electric current was used.

The bearing had been in service since December, 192[illegible] and there has been no complaint of any trouble since. Its dimensions were 3 feet long and 15 inches wide.

COLLAR OF THERMIT WELD ALLOWS GROOVE INSPECTION

The one fact that has been more responsible than any other for retarding the progress of welding, according to a statement by the Metal & Thermit Corporation, New York, is that when a weld is made it is impossible to determine without destroying it what strength is definitely assured and safe to allow. An examination of the surface of welds does not reveal this. It is on this account that certain well-known technical societies and associations interested in the possibilities of welding have greatly restricted the allowable application.

A thermit weld, however, by reason of its collar allows a careful inspection and permits the drawing of proper conclusions as to the strength of welds. In thermit welding there is little danger of having such defects as lack of fusion (if the proper amount of thermit has been used and instructions have been carefully followed), or oxide inclusions. Unclean surfaces, oxide inclusions (due, for example, to failure to properly clean scale from wrought iron sections before welding) have always resulted in thermit welding in only one type of defect, i. e., blow holes. This defect, due to the natural tendency of the gases to rise in the molten mass, if present at all, will be present in the thermit steel collars, and an examination internally of the collar can be made without affecting the strength of the weld. Thus the unsound welds can be found and condemned.

In practice, this examination is made by gouging deep grooves in the thermit steel collars parallel with the axis of the piece, these grooves reaching almost to the original section itself. Two such grooves on the four sides of a thermit weld have been found to be sufficient. If these grooves are observed to be free and clean from blow hole defects, the inspector may be reasonably assured that the weld itself is sound.

NEW ACETYLENE PREHEATING TORCH

A new type of preheating torch, burning acetylene gas, is being announced by the Weldit Co., 510 New Jersey Ave., N.W., Washington, D. C. This would seem to be a luxury at first glance, but the manufacturers claim that it does the work so quickly and is so free from trouble that it has a real place in the day's work. The torch is constructed on the Bunsen burner principle, has no loose or moveable parts, and burns acetylene with air. It heats small parts quickly and is very useful for such awkward jobs as straightening an axle under the automobile. The torch can also be used for brazing.

TORCH SAVES STEAM DOME AND FARMERS' TIME

By L. S. Huling

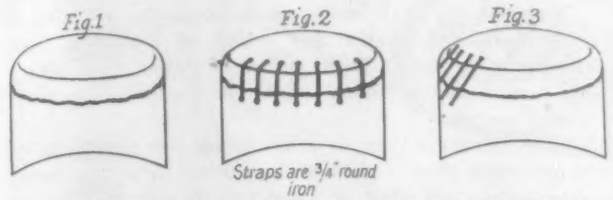
Out on the wheat fields of Kansas, interruptions to the business of threshing are very costly. Seasons must be reckoned with as well as balky, unwieldly machinery. It is enough to have a spell of weather butt in on the threshing job, but it is too much if the machinery breaks down.

It sometimes happens that the machinery does give out and the failure of a steam dome on a threshing engine furnishes the basis for this discussion.

Huling & Sons, welders in Brownell, Kansas, were called to the crippled thresher after the job of repair had been turned down by

others as impossible. The crack in the dome was a mean one and required a good deal of skillful head and hand work, but the Hulin concern did not stop just because the job is hard. Instead they went right ahead and made a successful job of the dome and put it back in service.

The crack was 17 inches long and followed the line of roll in the dome as shown in Figure 1. After preparation of the crack for welding, the weld was made after the fashion of a regular



Straps Were Used Here Because Staybolts Were Not Available.

boiler seam. Upon cooling, the job was further reinforced by several straps as shown in Figure 2. Staybolts would have been more desirable in the place of the straps but there were no staybolts available. The straps served just as well, anyway.

The nearest boiler shop was about 100 miles away and the delay to the thresher would have been very costly. Not only would he have had to wait for the new dome to be flanged and fabricated but he would also have had to wait until it was installed. Meanwhile a thousand other things could happen that would queer his chances of getting the threshing out of the way.

TRANSPORTATION ENGINEERING CORPORATION CHANGES LOCATION

Announcement is made by the Transportation Engineering Corporation that they have changed their location from 200 Fifth Avenue, New York to 15 Park Row, New York.

PATCHING AN OIL WELL CASING

By R. R. Palmer

While reading the evening paper recently I noticed an account of an accident at a local mine, caused by a coal cutting machine cutting into the casing of an oil well, filling the room with gas, the gas igniting from the miner's lamp and severely burning him.

I immediately began wondering what I would do if I had a mine in such a condition, and, naturally as I am a welder, my first thought was, "why not weld that casing." But the mine was full of gas which made the job of welding said casing seem less attractive. A few days later I was thinking about the accident when I met the superintendent of the mine. He immediately informed me that he would like to have some welding done. I asked him what he had and he said he wanted to get some six inch pipe welded. I asked him where it was and he said about two miles under the ground and related the incident to me.

We loaded the outfit in the truck along with a tank of each gas and proceeded to within about one mile of the mine where the road apparently ended. The superintendent went to the mine and sent a man with two bank mules to haul our tanks.

We fastened the rope to the top of each tank, laid the tanks on their sides and let the mules drag them through the mud. Arrived at the mine, we loaded the tanks in a coal car, hooked up the outfit and entered, each carrying an electric torch for lighting purposes.

The valve had been closed on the main gas line, shutting off the pressure of the rest of the wells, and a valve had been opened letting the gas escape from the well on which we were to work.

The mine fans were all running and very little gas could accumulate in the room in which we were to work although considerable gas was coming out of the hole in the pipe. We made a patch to fit over the damaged place. The hole in the pipe was about six by six inches, our patch being quarter inch by seven by seven inches. We wired the patch over the hole. I considered the best place to work was directly in front of the patch. Holding the torch close to the patch I scratched the flint and the flames were about three feet long on all sides of our patch. Of course it was very warm. The flames were shooting to the sides, top and bottom but not coming in my direction, and very soon the job was complete. The superintendent told me later that he had spent about one hundred and fifty dollars trying in different ways to stop the leak. Had a man from a nearby city with a clamping device, but to no avail. The welding cost less than twenty dollars.

With a clamp the casing could never be removed as the hole in the ground is just large enough to admit the pipe. By the welding process the patch was the size of the sleeve with which the pipes are connected and the pipe can easily be removed.

C. A. McCUNE NEW PRESIDENT OF AMERICAN WELDING SOCIETY

The annual meeting of the American Welding Society was held in the Engineering Societies Building, New York City, from April 26 to 29. The program included the reading of papers on welding and related subjects, and a series of discussions on the adoption of standard specifications and codes. At the technical session of the meeting three interesting papers were read. They were: "Welding of Heavy Copper Plate," by A. S. Kinsey; "Electric Welding of Dredge Pipes," by J. H. Nead and R. L. Kenyon; "Thermit Welding," by J. H. Deppeler. Separate sessions were held on electric-arc and gas welding. The committee on training of operators reported considerable progress along these lines and was authorized to continue its work during the next year.

The election of officers resulted in the selection of Charles A. McCune, of the Page Steel and Wire Co., Bridgeport, Conn., as president; W. H. Namack, of Ballston Spa., N. Y., vice-president for the New York and New England district; T. T. Oechsle, Philadelphia, Pa., vice-president for the middle Eastern district; W. A. Slack, Chicago, vice-president for the middle Western district. Directors elected were: James Burke, Erie, Pa.; Herman Lemp, Erie, Pa.; H. I. Walsh, Newport News, Va.; A. F. Jenkins, Baltimore Md.

ATTRACTIVE WELDING EXHIBIT

The accompanying photograph shows the exhibit of the Air Reduction Sales Company at the National Railway Appliances Association Exhibition held at the Coliseum, Chicago, March

Airco Exhibit at Railway Show.

13 to 16. The exhibition was well attended this year and this exhibit is reported to have been a valuable one, the company deriving considerable direct benefit as a result of this representation.

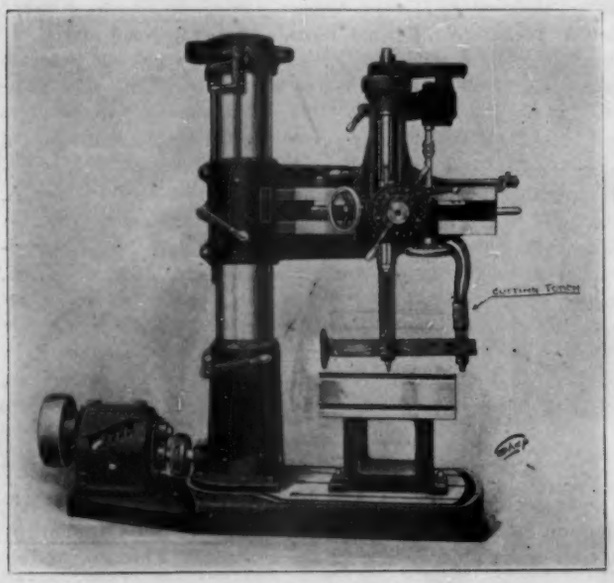
WELDED PIPE FITTINGS

Welded Fittings Are Less Than One-Half the Weight of Old Style Fittings, Cost Less and Are More Easily Handled

Butte, Montana.
Monday.

Dear Ed:—

Was mighty glad to find your letter of the 10th waiting for me here. If a fellow don't get word from his home town once in a while he sure does get lonesome. I note what you say about your friend Eubanks of Kansas City and his suggestions. You are the doctor, not me; if, as he says the addition of 25 per cent cyanide to the ordinary brazing flux helps as much as he says it does in the brazing of cast iron it's a good thing to know. If more fellows would write in their hints it would help the whole game. Naturally the proof of the pudding is in the eating they say so I'll be interested in learning just how you make out with Eubanks' tip on brazing. I don't quite get his other idea of taking care of expansion and contraction on aluminum crank cases



Drill Press Converted Into Mechanical Cutter.

but perhaps you do. If not, perhaps he'll explain it a little more fully sometime.

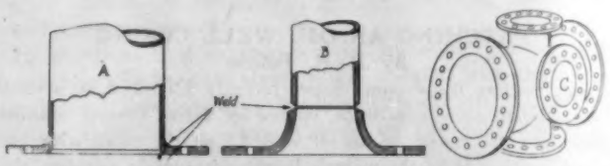
I didn't come across anything so very startling in the welding line here but just the same there is one thing I want to tell you about. You probably remember that about two years ago Butte completed a large welded pipe-line. It wasn't much different from others that you've heard about in California and the oil fields, except perhaps, that this one had to be laid over a mountain. The thing that interested me was that one shop after seeing this pipe line, conceived the idea of manufacturing large pipe fittings by the welding process. Did you ever see a fitting for a twenty-four or thirty inch low pressure water line Ed? They are immense things and weigh anywhere from five hundred pounds up to a ton or more, depending upon their size and design. Now the welded fittings are less than one-half the weight; can be handled more easily; can be manufactured for less money; they have practically no limits when size and shape is considered and in addition, if ever a time comes after an installation is made that a change must be made, the fitting need not be moved; it means simply that a cutting torch and one for welding will be about the only tools necessary to make any change.

I'm enclosing a sketch showing the type of fitting they were making up today. This welding was being done by the electric process but I see no reason why it couldn't be done by the oxy-acetylene just the same. The body, or main part, is made of ordinary pipe, cut to size and the same holds true of the offsets. These offsets after being cut to shape to fit the main body are then set in position and welded on, before the inner hole is cut in the body. When welded, a cutting torch with a straight head is used to remove the part of the main body inside the welded portion.

Really the flanges are the most interesting part of all. When I first examined them I thought they must have been turned out on a machine but when informed that they were all cut out with the torch then I wanted to know all about how it was done, for I'd never seen such smooth cutting in all my life. I asked the fellow showing me around how they did it and he spoke as follows:—

"When I tell you, my friend, that all those flanges you see have been turned out on a drill press, you will probably look at me twice to see if I'm joking but such is really the case. We have tried a lot of different stunts such as compasses, guides, revolving the work and so on but the result was more or less a rough job. That drill press, you see over in the corner nearest the door, is the one that does the trick. It had been discarded as a drill press but our foreman got ahold of it one day; geared it down to run very slow; arranged that adjustable arm on the spindle so that it would hold a straight head cutting torch and permit it to revolve but once."

"If we intend to run a number of flanges," he continued, "we



Three Views of the Welded Pipe Fittings.

Left: Showing how heavy flanges are welded both inside and out on extra large fittings. Center: A special flange design for welded high pressure piping. Note how weld is removed from face to prevent warping. Right: An extra large pipe fitting produced by welding, proves much more efficient than the cast variety.

pick out a plate of the proper thickness, set it up on 'horses', with one end under the spindle of the press. The arm is adjusted so that the tip of the torch is the proper distance from the center, then the flame is turned on. At the proper moment both the oxygen cutting jet and power are turned on simultaneously and it's almost impossible to have anything else result than a perfectly smooth edged circle. It's purely a mechanical movement and if the correct sized cutting tip and flame are chosen, the reaction will be complete and no slag will appear on the under side."

"What do you do with the centers of those large flanges?" I asked. "Surely they are not all wasted."

"Certainly not" he answered, "we cut smaller flanges from them."

I examined one of the fittings again to see how the welds were made and found that on the flanges they were welding them both inside and out. I'll make a little sketch of the cross-section to show what I mean. You will notice that the end of the pipe don't come flush with the outside edge of the flange but it stops about a quarter of an inch inside so that a nice "fillet" weld can be made there.

Now I don't know whether the foregoing is going to help you much in your shop or not but it may be the means of giving you some kind of an inspiration, if so all's well. But in this

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to keep in mind for I'm sure you'll have occasion to use the same shop I saw another fitting that ought to be one for you idea some day. This fitting is nothing more or less than a flange and it's intended to be used on welded high pressure lines where a joint, other than a weld is desired. The idea is to get the weld away from the face a little in order to prevent any warping. The flange is punched out, as I have shown, from a fairly heavy stock and welded to the pipe end where desired. They say it works out fine on high pressure lines so the next time you have a good sized steam installation you may want to try it.

Well, Ed guess I'll have to ring off for this time. My train is due in another hour and I have a couple of reports to finish up. I jump from here to Minneapolis and then in, so don't be surprised if I run down to see you in the near future.

Your old pal

Shep.

WELDING SAVES MONSTER GUN LATHE STEADY REST

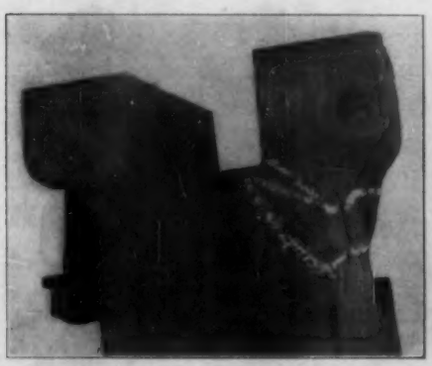
By H. LeLaurin

On account of the immense size of the forgings from which large naval guns are made, and also on account of the great swing room required in the lathe during the turning process, some huge lathes are necessary. The dimensions of these lathes vary a great deal, as they are required to perform numberless different sorts of operations. Our account deals with one of the large type machines on which a steady rest, the part that acts as stand or leg for the lathe bed, was broken across a flange.

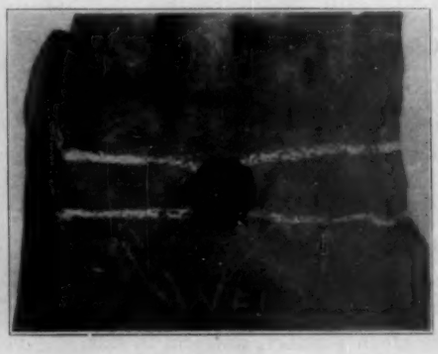
The part broke on gun lathe No. 3 in the United States Navy gun factory at Washington, D. C., and the story of its economical salvage by the welding process is quite interesting. Inasmuch as the broken section was a casting, it was necessary to preheat it before applying the oxy-acetylene flame. This was accomplished by the use of oil burning torches. These were trained on the casting in the area about the line of break until the piece was a cherry red. The portions of the rest which were not close to the line of break were not heated. After preheating, the welders commenced their work.

The steady rest weighed 5,940 pounds. The size of this job can be better realized if the reader will stop and think for a moment that 5,940 pounds is considerably more than 2 long tons. One huundred pounds of filler rod was required to close the breach. Approximately 1,933 cubic feet of oxygen were used. The job required 1,613 cubic feet of acetylene. The actual welding operation required about four and one-half hours of time.

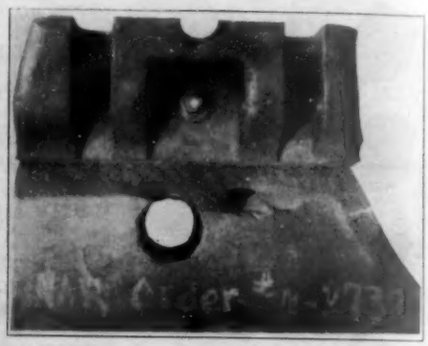
The photographs accompanying this article also help to bring out the immensity of the job. The total cost of labor and material to perform the repair was $154.00. To replace the broken steady rest with a new one would have cost at least $1,800.00. It will be noted that if there were no method of repair for this lathe section, a new one would have been purchased to replace it. This would have meant the loss of the difference between the two figures quoted plus a time loss that would not be easy to calculate.



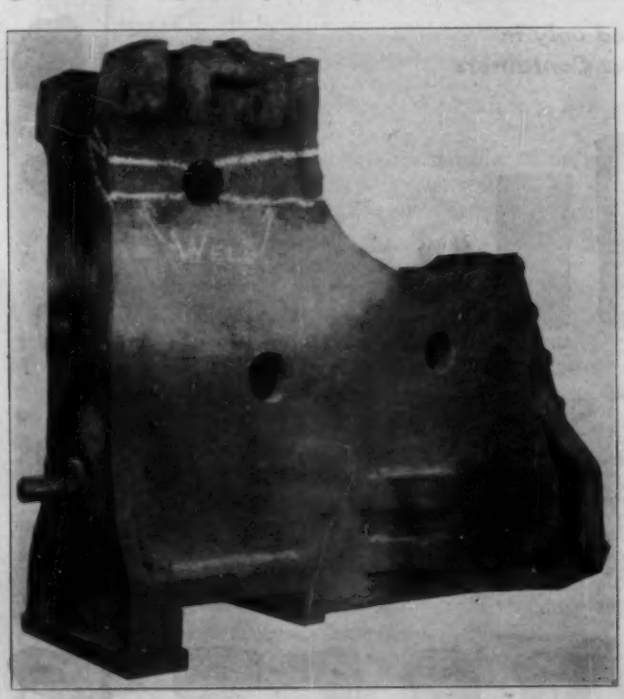
End View of Welded Casting.



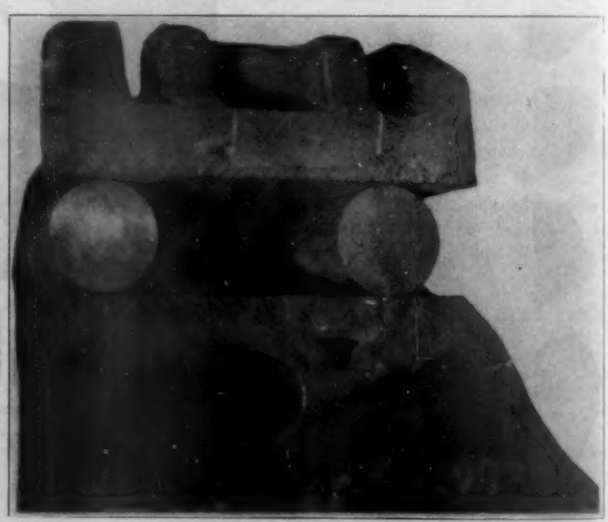
The Completed Job.



All Ready to Weld.



The Light Area Indicates Extent of Preheating.



Showing Break on Lathe Steady Rest.

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WELDING RODS and ELECTRODES

Strength of Arc Welded Pressure Vessels*

Results of Tests on Electrically Welded Containers and Specially Prepared Specimens of Welded Metal

By R. J. Roark†

THE investigation which forms the subject of this paper was made by the writer for the Vilter Manufacturing Company of Milwaukee, who furnished all test specimens. The tests on the containers were carried out at the works of the company. The tests on the specimens cut from the containers and on the specially prepared specimens were made in the materials testing laboratory of the University of Wisconsin.

2. The writer wishes to acknowledge the helpful co-operation of the officers of the Vilter Manufacturing Company, their readiness to submit their product to any test suggested and their promptness in furnishing the necessary specimens and appliances. Thanks are due for helpful suggestions to Prof. G. L. Larsen, professor of Steam and Gas Engineering at the University of Wisconsin, who witnessed the tests on containers.

TABLE 1—RESULTS OF PRESSURE TEST ON CONTAINERS

Specimen Number	Description of Specimen	Pressure in Lb. per Sq. In. at: First observed Leakage	Pressure in Lb. per Sq. In. at: Dishing of Heads	Pressure in Lb. per Sq. In. at: Maximum	Method of Failure	Stresses on Head Joint at Maximum Pressure: Longitudinal Shear, Lb. per Linear Inch of Joint	Radial Tension, Lb. per Linear Inch of Joint	Bending Moment Inch-lb. per Linear Inch of Joint	Max. Resultant Shearing Stress, Lb. per Sq. In.	Max. Resultant Tensile Stress, Lb. per Sq. In.	Remarks
1	Standard commercial container with electrically welded heads. Size 16 in. x 10 ft.	1925 (1820)	....	2150 (2040)	Longitudinal crack started at nipple	7770	870	1780	9800	15000	....
2	Standard type container with gas welded heads. Size 16 in. x 10 ft.	....	2150 (2040)	2200 (2090)	Head forced off	7960	900	1820	10500	16000	Fracture on section B-B
3	Standard type container with riveted heads. Size 16 in. x 10 ft.	1200 (1120)	....	2100 (2000)	Excessive Leakage	....	....	....	....	....	....
4	Container with gas welded heads and gas welded longitudinal butt joints. Size 16 in. x 5 ft. (Weld by Le Quelle)	....	....	1600 (1540)	Split along long. butt weld	....	....	....	....	....	....
5	Container with gas welded heads and gas welded longitudinal butt joints. Size 16 in. x 5 ft. (Weld by Vilter)	....	....	1300 (1240)	Split along long. butt weld	....	....	....	....	....	....
6	Container with electrically welded heads and electrically welded longitudinal butt joints. Size 16 in. x 5 ft.	....	....	1400 (1340)	Split along long butt. weld	....	....	....	....	....	....
7	Reinforced container with electrically welded heads (3 concentric shells, concrete filled). Size 10 in., 12 in., 14 in. x 3 ft. 2 in.	....	4500 (4800)	4800 (4680)	Head forced off	11860	....	....	18000	....	Fracture on on sections B-B, C-C
8	Reinforced container with gas welded heads (3 concentric shells, concrete filled). Size 10 in., 12 in., 14 in. x 3 ft. 2 in.	4350 (4230)	4100 (3980)	4350 (4230)	Excessive leakage at weld joints	10720	....	....	....	....	....
9	Special container with one head electrically welded; one head riveted. Size 16 in x 2 ft.	1750 (1670)	....	2500 (2390)	Split along lap weld	9100	....	....	11600	17600	....

Purpose and Scope of the Investigation

3. The primary purpose of this investigation was to demonstrate the strength and uniformity of a certain type of commercial pressure container with electrically welded head joints. These containers were made of lap-welded pipe and were provided with spherical flanged heads. Their dimensions are given in Fig. 1. The average physical and chemical properties of the steel used, as reported by the company furnishing it, were as follows: Yield point, 38,000; ultimate, 64,000; elongation, 27 per cent; carbon, 0.17 per cent; manganese, 0.44 per cent; phosphorus, 0.01 per cent; sulphur, 0.027 per cent. It was proposed to determine the absolute strength of such containers by pressure tests on representative samples and to establish a comparison with vessels of like form and dimensions, but with gas-welded and riveted heads, by similar tests on such containers. In order to secure a more positive check on the uniformity of the joints and more specific information as to their strength under various conditions of stress, it was planned to cut from the containers specimens of such form as to give, when subjected to laboratory tests, the desired information. Partly to determine the best form for such specimens and the best method of testing them, and partly to aid in the interpretation of results, strain measurements were made on certain of the specimens during the tests. From these measurements relations were established between the internal pressure in a vessel of the standard type and the resulting stresses on the head joint.

4. In order to gain still more detailed information concerning the physical properties of welded joints, various special specimens of welded metal were made up and tested as subsequently described.

5. It is thus seen that the investigation comprised three more or less distinct series of tests, namely, tests on containers, tests on specimens cut from containers and tests on special specimens of welded metal.

Tests on Containers

6. In all, nine containers were tested. In each case, the test consisted of subjecting the specimen to an internal hydraulic pressure which was gradually increased until rupture resulted or such rapid leakage developed as to make further increase of pressure impracticable. Pressure was in most cases applied in predetermined increments by a hand pump, and was measured by an indicating gage which had been calibrated immediately before its use in these tests.

7. Some of the specimens were of standard design. Some were so made as to secure failure of a particular sort in order to provide information on some specific point. In order to compare the work of different operators, two similar gas-

*Paper presented at the Spring Meeting, Atlanta, Ga., May 8 to 11, 1922, of the American Society of Mechanical Engineers, 29 West 39th Street, New York.

†Asst. Prof. Mechanics, University of Wisconsin.

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welded specimens were made up, the welds being made by different operators. On certain of the containers of standard design, strain measurements were made as mentioned above.

8. The various tests are described separately below, and a summary of the results obtained is presented in Table 1. Accompanying photographs show the appearance of the specimens before and after testing, and indicate the manner of failure. The results of the strain measurements and the way in which they were used to determine stresses are presented subsequently in a special discussion, under the heading Stresses on Head Joints. Pressures mentioned below are nominal pressures as indicated by the gage readings. Corrected values, taken from the calibration curve for the gage used, appear in parentheses in Table 1. All stresses were computed from these corrected pressures, which are in general about 3 per cent less than the corresponding nominal pressures.

TABLE 2 TESTS OF SPECIMENS CUT FROM CONTAINERS

(Results of Tension Tests on Specimens of Type A)

Specimen No.	Container from which Specimen was Cut	Dimension of Specimen			Ult. Load	Moment at Ult.	Max. Ten. Stress (Computed)	Method of Failure
		Width of Specimen "a" In.	Width of Weld "b" In.	"e" at Ult. Load In.	Lb.	In.-Lb.	Lb. per Sq. In.	
1	No. 1 — 16 inch electrically	2.00	0.9	2.40	5000	8000	32000	Shell broke transversely
2	welded previously tested	2.00	0.8	2.25	4170	6250	32000	Weld broke transversely
3	No. 4 — 16 inch	2.00	0.8	2.10	4650	6500	33500	Shell broke transversely
4	gas welded	2.00	0.7	2.26	3700	5550	36500	Weld broke and tore trans.
5	previously tested	2.00	0.8	2.75	4070	7450	37500	Shell broke transversely
6	(weld by Vilter Co.)	2.00	0.8	2.60	3730	6450	32500	Weld tore
7	No. 5 — 16 inch	2.00	0.8	2.62	3080	5350	27000	Weld tore
8	gas welded	2.00	0.8	2.65	4100	7250	36500	Weld tore
9	previously tested	2.00	0.6	2.32	2880	4450	39500	Shell broke transversely
10	(weld by Le Quelle)	2.00	.....	.....	.....	.....	.....	Weld tore
11	No. 10 — 10 inch	2.00	0.7	2.30	4170	6400	42500	Shell split
12	electrically welded	2.00	0.6	2.23	3250	4800	43000	Weld broke transversely
13	not previously	2.00	0.7	2.27	4250	6400	42500	Weld tore
14	tested	2.00	0.6	2.11	3400	4800	43000	Shell split
15	No. 3 — 16 inch	.....	.....	1.35	19250	.....	.....	Rivet head sheared off
16	riveted	.....	.....	1.40	19850	.....	.....	Rivet pulled in two
17	previously tested	.....	.....	1.60	21000	.....	.....	Rivet pulled in two
19	No. 11-10 inch	.....	.....	1.45	8240	.....	.....	Outside rivet head sheared
20	riveted	.....	.....	1.25	8120	.....	.....	off in each case
21	not previously	.....	.....	1.50	8250	.....	.....	
22	tested	.....	.....	1.60	7340	.....	.....	

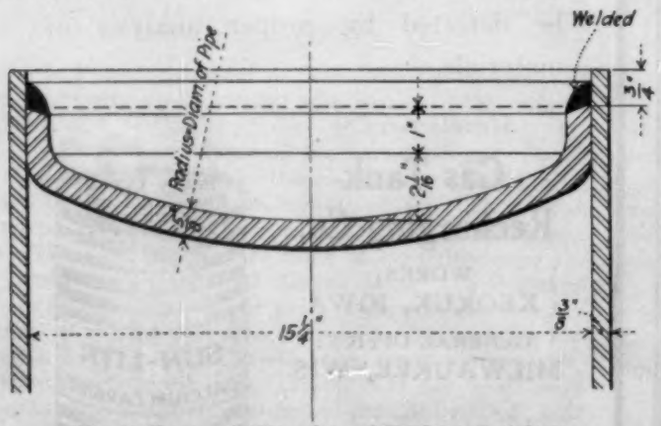

Fig. 1—Shape and Dimensions of Specimen Containers.

Specimen No. 1

Description: 16-in. by 10-ft. standard, commercial container with electrically welded heads.

Method of Testing: Successive pressure of 200, 400, 800, 1,200, 1,600, and 1,750 lb. per sq. in. were applied. The pressure was reduced to zero after each specified application. Strain measurements were taken at each of the above pressures. The maximum pressure was then applied.

Behavior: At a pressure of 1,750 lb. per sq. in. the welding started to leak. The tank had visibly increased in diameter and the elastic limit had evidently been exceeded. At a pressure of 1,925 lb. per sq. in. leakage occurred at the weld of the nipple. A new nipple was welded on and the pressure increased to 2,150 lb. per sq. in. when the specimen ruptured. Failure was due to circumferential tension in the shell. The fracture commenced at the nipple, whence it proceeded to and along the lap weld in the pipe composing the shell. The heads did not reverse.

Specimen No. 2.

Description: 16-in. by 10-ft. container of standard form with gas welded heads.

Method of Testing: Successive pressures of 500, 1,000, 1,500 and 1,800 lb. per sq. in. were applied. Strain measurements were made at each pressure up to and including 1,500 lb. The pressure was not reduced to zero after each application, but was maintained and increased to the maximum without release.

Behavior: No difficulty was experienced on account of leakage. At a pressure of 2,150 lb. per sq. in. one of the heads reversed. At a pressure of 2,200 lb. per sq. in the specimen ruptured, the reversed head being violently forced off. Failure was due to combined longitudinal tension and bending; fracture occurred on a circumferential section of the shell adjacent to the welded joint. There was also a crack in the outside face of the welded metal, indicating a local failure due to bending. The circumstances of this failure are discussed more in detail under the subject of Stresses on Head Joints.

Specimen No. 3

Description: 16-in. by 10-ft. standard, commercial container with riveted heads.

Method of Testing: Successive pressures of 200, 400, 800, 1,200, 1,600, and 1,800 lb. per sq. in. were applied. Strain measurements were made at each such pressures, and the pressure was reduced to zero after each specified application.

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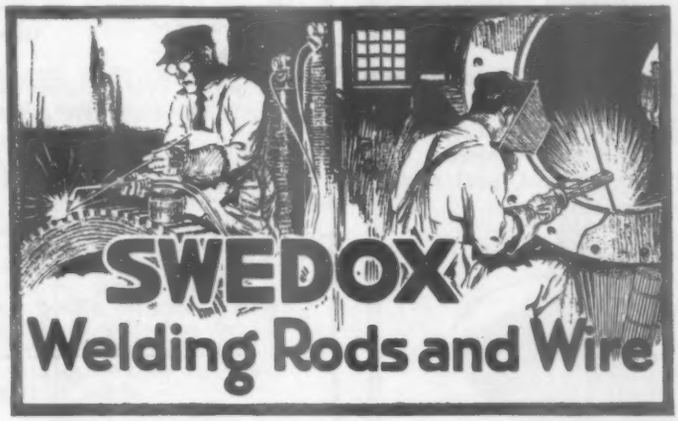

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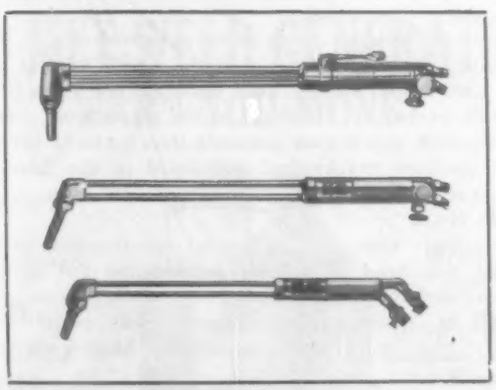

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Behavior: At a pressure of between 1,200 and 1,600 lb. per sq. in. leakage was observed at both ends next the rivets and in the weld at the nipple. The nipple was replaced and the test continued. At a pressure of 1,800 lb. per sq. in. leakage became so bad that it was found impossible to increase the pressure further by hand. The specimen was therefore connected to a power pump and a pressure of 2,100 lb. per sq. in. obtained, when leakage again prevented further increase. The container did not rupture and the heads did not reverse.

Specimen No. 4

Description: 16-in. by 5-ft. container of standard form with gas-welded heads and gas-welded longitudinal butt joint Welding by Le Quelle.

Method of Testing: The container was subjected to a steadily increasing pressure, applied by hand, until rupture resulted.

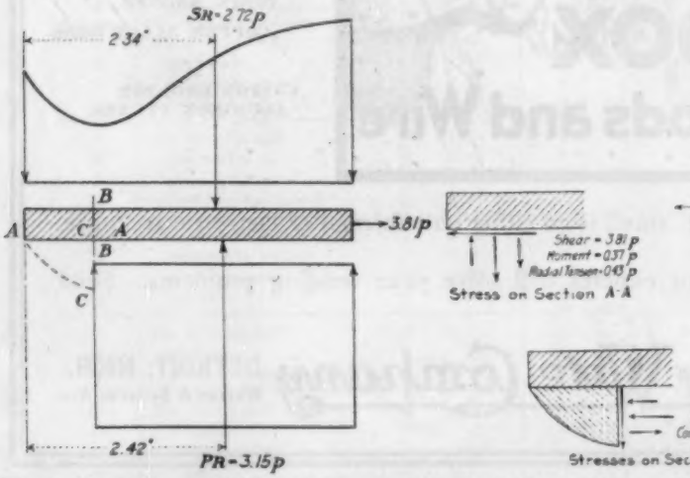

Fig. 2—Stress, Shear and Moment Diagrams of Container.

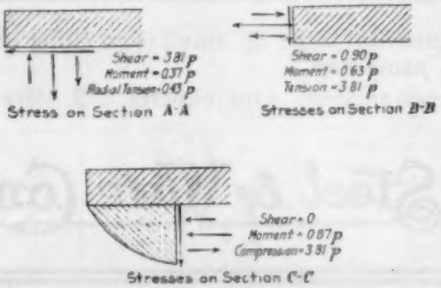
Shear = 3.81 p
Moment = 0.37 p
Radial Tension = 0.43 p
Stress on Section A-A
Shear = 0.90 p
Moment = 0.63 p
Tension = 3.81 p
Stresses on Section B-B
Shear = 0
Moment = 0.87 p
Compression = 3.81 p
Stresses on Section C-C

Fig. 3—Stress, Shear and Moment Diagrams.

Behavior: The head through which the water was admitted reversed at a pressure of 4,500 lb. per sq. in. The other head reversed at a pressure of 4,800 lb. The pressure fell off and when again increased, rupture occurred at 4,750 lb. The head through which water was admitted was forced off. Failure was due to combined bending and tension. Fracture occurred partly in the shell and partly in the weld, along the front edge of the head flange. This failure is discussed more fully under the subject of Stresses on Head Joints. Failure in this case was sudden, the head being forced off with considerable violence.

Specimen No. 8

Description: This specimen was similar to specimen No. 7, except that the ends were gas-welded.

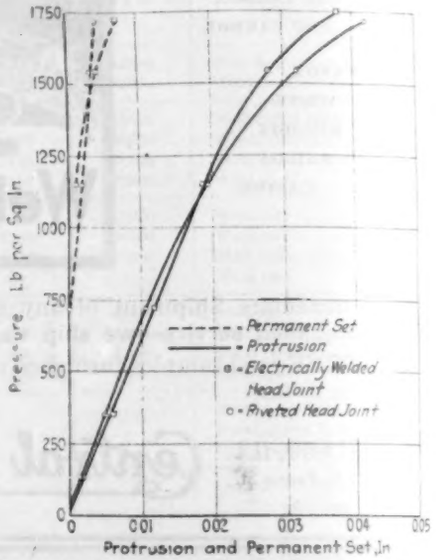

Fig. 4—Protrusion and Permanent Set of Container Heads at Different Pressures.

Behavior: No leakage occurred. The heads did not reverse. The specimen ruptured at a pressure of 1,600 lb. per sq. in. Failure was due to circumferential tension. The fracture occurred along the welded butt joint. Failure was sudden, the tank splitting along nearly the entire length of the butt weld with a loud report.

Specimen No. 5

Description: 16-in. by 5-ft. container of standard form with gas-welded heads and gas-welded longitudinal butt joint. Welding by Vilter.

Method of Testing: Same as with specimen No. 4.

Behavior: Similiar to specimen No. 4, except that failure occurred at a pressure of 1,300 lb. per sq. in.

Specimen No. 6

Description: 16-in. by 5-ft. container of standard form with electrically welded heads and electrically welded longitudinal butt joint.

Method of Testing: Same as for specimens Nos. 4 and 5.

Behavior: Similar to specimens Nos. 4 and 5, except that failure occurred at a pressure of 1,400 lb. per sq. in.

Specimen No. 7

Description: This specimen was especially designed to insure failure taking place at the head joint. It consisted of three shells, one 10 in., one 12 in. and one 14 in. in diameter, placed concentrically, the annular spaces between being filled with portland cement mortar grouting. The heads were electrically welded. The length of the container was 2 ft. 3 in. Water was admitted through a small hole at the center of one end and another hole, ⅛ in. in diameter, was provided near the edge of the head as an air escape.

Method of Testing: The specimen was subjected to a steadily increasing pressure, applied by hand, until rupture resulted.

Method of Testing: Same as for specimen No. 7.

Behavior: Leakage occurred at the nipple weld at a pressure of 3,200 lb. per sq. in. Both heads reversed at a pressure of 4,100 lb. per sq. in. Leakage at the nipple weld prevented the application of a higher pressure than 4,350 lb. per sq. in. At this pressure cracks had developed in the head weld, through one of which leakage occurred.

Specimen No. 9

Description: Container of special construction, 16 in. by 2 ft. with one head electrically welded and one head electrically welded and stay-riveted.

Method of Testing: The specimen was subjected to a steadily increasing pressure, applied by hand until rupture resulted.

Behavior: Some leakage occurred at the riveted head at a pressure of 1,750 lb. per sq. in. Rupture occurred at 2,500 lb. per sq. in. Failure was due to circumferential tension. Fracture occurred along the lap-weld of the pipe which formed the shell.

Stresses on Head Joints

9. During the tests on specimens Nos. 1 and 2, strain measurements were made at sections distant 1 in., 2 in., 3 in., and 5 in. from the end. The measurement at the end was made on a diameter by means of a wire-wound dial reading to one ten-thousandth of an inch. The other measurements were made in one case by means of a Berry strain gauge, on a 2-in. gauge line, and in the other case by means of wires which encircled the container and which were provided at both ends with lugs, between which measurements could be made to one-thousandth of an inch by means of an ordinary micrometer. Owing to the danger of explosive failure, readings were taken only up to about three-fourths the computed bursting pressure.

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10. From the measurements thus made, the stress at each section was computed, employing as the value of the modulus of elasticity, 29,000,000 lb. per sq. in. The stress at each section was then expressed as a percentage of the stress which would exist in a similar cylinder having the same internal pressure and not subject to end restraints. By plotting for each section a diagram of stress against pressure up to the maximum pressure at which readings were taken, the probable stress at bursting pressure (taken for this purpose as 2,000 lb. per sq. in.) was determined by extrapolation. A diagram was then plotted in which these stresses (expressed as percentages of the normal stress) were used as ordinates and distances from the end of the specimen to where these stresses occurred were used as abscissae. The resulting diagram is shown in Fig. 2. In this figure a portion of the shell is shown with the radial forces which act upon it. The inward forces (shown acting down) consist of the radial components of the circumferential stresses, determined as explained above. The outward forces (shown acting up) consist of the uniform internal pressure, which of course extends only to the beginning of the weld. The portion of the shell shown is in equilibrium under these forces and the stresses acting, and by applying the appropriate conditions of equilibrium the stresses on each of the important sections A-A, B-B, and C-C, were determined. They are represented in Fig. 3. In the determination of these stresses the bending moment and shear at the section where the circumferential stress becomes equal to the stress which would exist if there were no end restraint, are assumed to be zero. This is not strictly correct, but it is not believed that the assumption introduces a considerable error.

11. The stress on section C-C depends upon the tension in the band of welded metal (shown in dotted outline), and as the section area of this band is non-uniform and difficult

Figs. 5 and 6—Forms of Specimens Subjected to Shear and Flexure.

to determine, it is probable that the stresses as computed for this section are more in error than the others. All of the results given are to be regarded as approximations. They represent the nature of the stresses existing and the order of their magnitude, rather than their precise values. A rough check upon the correctness of these computed stresses is afforded by the manner in which the standard gas-welded container (specimen No. 2) failed and the pressure which caused rupture. This specimen failed on section B-B and the form of fracture showed very clearly that the failure was principally due to flexure. The corrected pressure at rupture was 2,090 lb. per sq. in. Using this as the value of P and computing the maximum fiber stress from the tension and moment indicated by Fig. 3 (B-B), and the known thickness of the plate, a value of 77,000 lb. per sq. in. is obtained, which agrees very well with the modulus of rupture of the metal as determined by other tests. It will be noted that so far as conditions at the ends are concerned, section (B-B) is the weak point in the standard containers, as would be expected from the thinness of the metal there and the large bending moment, accompanied by direct tension. Section C-C appears to be the next weakest point. Local failure occurred on this section in specimen No. 2 and in the case of the reinforced specimen No. 7, about half the fracture was on section B-B and half on C-C. Apparently the surface of contact between the weld and the shell (section A-A) is stronger than either of the other two sections and in no case did failure take place on this section.

12. The values given for maximum shearing stress and maximum tensile stress in Table 1 were computed for sections A-A. It is to be noted that they do not represent the strength of the material in shear and tension, but simply the approximate shear and tensile stress produced in the welded joint by a pressure which caused failure at some other point.

13. In order to compare the stiffness and elasticity of the welded and riveted types of containers, measurements were made to determine the protrusion and permanent set induced in the heads of certain of the specimens by the pressures applied. These measurements, which were made on containers No. 1 and No. 3, were taken to the nearest one-thousandth of an inch by means of Ames dials, readings being taken during the application of each pressure and after its release. The value given for protrusion and set represent respectively the total and the permanent displacement of the center of the head with respect to the end of the cylindrical shell. The data obtained from these measurements were used in plotting the curves of Fig. 4.

Tests of Specimens Cut from Containers

14. It is apparent from the stresses represented in Figs. 2 and 3 that the important stresses on the head joint are shear and tension, the latter being largely due to flexure. It appeared advisable therefore to cut from the containers specimens of such form as to make it possible to subject portions of the joint included therein to shear and flexure. Two forms of specimen were decided upon. Their form and the part of the container from which they were cut are represented in Figs. 5 and 6.

15. Specimens of type A were tested in tension, the ends being held in wedge grips. The breaking load, eccentricity at rupture and manner of failure were noted. From the data thus obtained, the computed ultimate tensile stress on the weld was determined. The results of these tests are presented in Table 2.

EFFICIENCY OF MACHINE CUTTING

(*Continued from page* 23.)

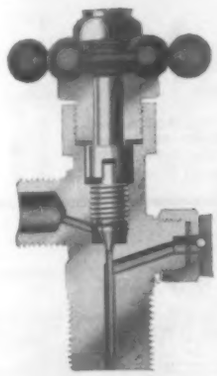
will note the operator is guiding the power driven tracer along the lines on template while a cutting torch on each end are cutting the plates.

Photograph No. 23 plainly shows the condition of these plates after cutting was completed. Several hundred of these plates were cut on this machine.

Photograph No. 24 shows a 900 pound steel forging that is called a fishing tool and is used in the oil fields for fishing out broken tubes that have been sunk. There are two cuts on this tool, each one having ten lineal feet of cutting, the thickness being 2½ inches. The combined time for two cuts being 21 minutes. The old method of doing this was to drill a hole in each end of cut, then cut the section with a hand torch. The methods we employed, you will note, effect considerable saving and time.

Photograph No. 25 shows this tool after cutting. You will also note the pattern or template on right side of machine.

The question has been raised as to whether the oxy-acetylene cutting operation causes any chemical change in die plates. The best information available indicates a softening effect when cut hot, extending about ¾ inch and as ⅞ inch is allowed for safety it can be safely said that no chemical change results in the completed die. It should be remembered that hot cutting is very fast, a factor which greatly diminishes the liability of injury.



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Of The Welding Engineer, published monthly at Chicago, Ill., for April 1, 1922.
State of Illinois,
County of Cook
ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared L. B. Mackenzie, who, having been duly sworn according to law, deposes and says that he is the Publisher of the Welding Engineer, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:
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2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)
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L. B. Mackenzie, 7131 Crandon Ave., Chicago, Ill.
M. J. Hungerford, 6107 Dorchester Ave., Chicago, Ill.

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ELECTRIC WELDING FOR SHIPS—Abstract of a paper read before the Institution of Mechanical Engineers, calling attention to the various ways in which welding is being applied to ship construction and indicating further possibilities in this connection for steel structures. Advantages of welding application of welding on the "Fullagar." Preparation and erection. Weight of the structure. Finish plating and water testing. If an attempt is made to cheapen welding at the cost of efficiency the future of the industry is imperilled and its development will be retarded for many years. —Acetylene and Welding Journal, London, April, 1922.

PAGE-ARMCO WELDING RODS AND ELECTRODES—Hand book published by Page Steel and Wire Company, Bridgeport, Conn. Describes the manufacture of Armco Ingot Iron and the drawing of wire in the wire mills. Lists principal industries using fusion welding processes. Gives American Welding Society specifications for welding rods and electrodes and several useful tables of general welding information.

OXY-ACETYLENE WELDING, by F. S. Tinder—A general treatment of the properties of acetylene, carbide and oxygen, and the development of the oxy-acetylene welding process. The importance of training welders and furnishing proper supervision. Suggestions for the beginner. Necessity for annealing. Welding procedure on Virginian Railway.—Official Proceedings of the Car Foremen's Association of Chicago, March.

NECESSITY AND EFFECT OF ANNEALING WELDS, by Robert G. Mason—How the proper heat treatment refines the structure of welded metal and relieves internal strains. Why preheating should be carefully done. Some simple tests of the value of annealing. Line drawings illustrate changes in the structure and the effect of these changes on the strength of the piece. This discussion takes a simple, practical point of view and does not go deeply into the technical side.—Railway Purchases and Stores, May.

INSTALLING AND MAINTAINING CHARCOAL IRON LOCOMOTIVE BOILER TUBES, by G. H. Woodroffe and C. E. Lester—Second installment of a series of suggested standard boiler tube practice. Deals with the use of welding in tube work, particular emphasis being placed on recommended maintenance practice in engine houses.—Railway Mechanical Engineer, May.

PRINCIPLES OF OXY-ACETYLENE FUSION WELDING, by A. S. Kinsey—An introductory article discussing the manufacture and the chemistry of acetylene, the properties of acetylene, how it is kept safe in solution and how measured.—Railway Mechanical Engineer, May.

WELDING OF CUTTING BLADES—Making a T-weld of two blades is a difficult operation because the thickness of the parts is constantly decreasing and the torch which is large enough for the base is too large for the edge. Good results can be obtained by using the "single-V" design, selecting a tip of the proper size for welding the smallest thickness, and using an auxiliary torch to heat the thick section from the side opposite the weld while the heavier portions are being welded.—Revue de la Soudure Autogene. March.

SUCCESS OF ELECTRIC WELDING, by E. Wanamaker—Careful preparation of work preceds welding. Finished welds are inspected to determine the quality of the workmanship. Welding equipment is purchased under specifications. Coated electrodes are used for all welding. These are reasons given for good results secured on the Rock Island Lines.—Electrical Review and Industrial Engineer, April.

WELDING IN A CONSTRUCTION CAMP, by J. C. Blake—A few examples of the value of a welding outfit to a large hydro-electric development project in an isolated location.—Acetylene Journal, May.

WELDING AT MINE AND MILL—The need for permanent welding shops for reconstruction work in metal mining industry. Layouts for large and small oxy-acetylene welding shops.—Acetylene Journal, May.

THE NEW TINSMITH'S HELPER AND PATTERN BOOK, by H. V. Williams—A textbook and working guide for the apprentice. Gives a practical explanation of mensuration problems which occur in the tinsmith's work and tells how to lay out and cut a variety of common jobs. A chapter of tables gives practically all the data a sheet metal worker desires. Information is also included on tin roofing, corrugated iron work, laying metal shingles, etc. 458 pages, 248 figures and 165 tables. Bound in cloth. Published by U. P. C. Book Co., New York City.

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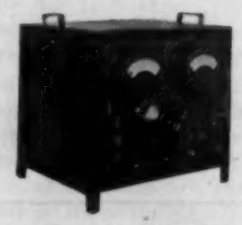

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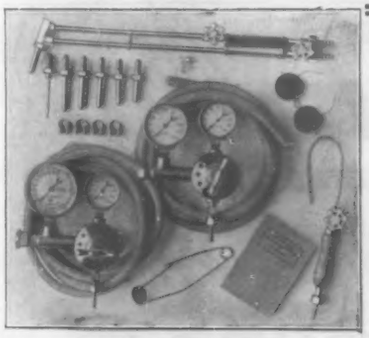

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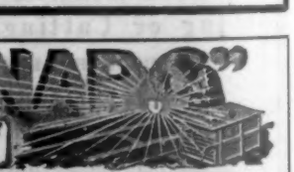

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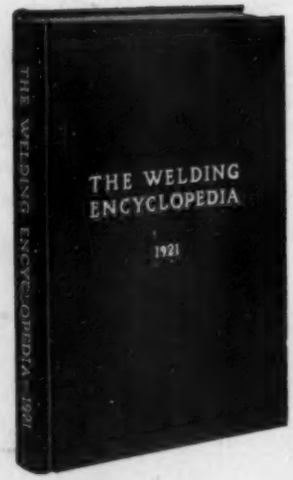

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